

# The Lower Lias of Robin Hood's Bay, Yorkshire, and the work of Leslie Bairstow

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**SYNOPSIS.** Rocks of Lower Liassic (Sinemurian and Lower Pliensbachian) age exposed in Robin Hood's Bay, near Whitby, north Yorkshire, are described from the mapping, stratigraphical descriptions and ammonite collections made by Mr Leslie Bairstow in the years 1927–1970, and preserved in the Palaeontology Department, The Natural History Museum, London. His large-scale map of the geology of the foreshore is published on five sheets at a scale of approximately 1:5000. The stratigraphical sequence from bed 418 at the base up to bed 600.5 at the top of the Lower Pliensbachian is 163.74 m thick, and consists of the Redcar Mudstone Formation, for which four members are formally defined – the Calcareous Shale (at the base), Siliceous Shale, Pyritous Shale and Ironstone Shale Members – overlain by the lower part of the Staithe Sandstone Formation. The lowest beds exposed by the lowest spring tides are Sauzeanum Subzone, Semicostatum Zone, in age; ammonites occur in all subzones, and the only uncertain boundary is that between the Masseanum and Valdani Subzones (Ibex Zone), where there are few characteristic ammonites. Bairstow's ammonite collection consists of more than 2360 specimens, all from recorded horizons, and is notably rich in *Promicroceras*, *Asteroceras*, *Eparietites* and *Oxynotoceras* from the Obtusum and Oxynotum Zones, Echioceratids, *Eoderoceras* and *Apoderoceras* from the Oxynotum, *Raricostatum* and *Jamesoni* Zones, and Liparoceratids from the Davoei Zone, making it a primary source for Sinemurian and Lower Pliensbachian ammonite biostratigraphy. The recently proposed selection of Wine

Haven at the south-eastern end of the bay as the Global Stratotype Section and Point (GSSP) for the base of the Pliensbachian Stage (ie. the world standard definition), is supported by the sequence of ammonites across the Sinemurian/Pliensbachian boundary. All previously figured ammonites from Robin Hood's Bay are listed in a systematic section that includes the evidence on which the ammonite identifications in the paper are based, and 56 of the best preserved ammonites are figured. *Eparietites bairstowi* sp. nov. is proposed for an early species of *Eparietites* and a Sowerby Collection ammonite from the Aplanatum Subzone, *Raricostatum* Zone, in the bay, is designated neotype of *Eoderoceras armatum* (J. Sowerby).

## INTRODUCTION

The geology of Robin Hood's Bay (Fig. 1) has received the attention of many geologists since the 1820s. One such geologist was Leslie Bairstow, who decided to make the description of the outcrops of the Lower Lias on the foreshore of the bay (Fig. 2) the main scientific work of his life. He started serious investigations in 1928 and worked in the bay for the next 50 years. Dr L.F. Spath, a colleague at the British Museum (Natural History) (now the Natural History Museum, London), identified the many ammonites that he collected and brought to the Museum. As long ago as 1956 Spath (1956: 147) referred to 'the (still undescribed) collections made by Mr L. Bairstow in Robin Hood's Bay', but Bairstow was never able to finish a detailed account for publication, and finally he left his work for me to complete. That completion has involved more fundamental work than mere editing: complete rewriting of the stratigraphical section, revision of the maps, preparation of many tables and diagrams not envisaged by Bairstow, and revision of the determinations in order to produce an up-to-date account of the ammonites and the biostratigraphy, were all found to be necessary. The final result is eminently worth publishing, if only because it would be very difficult to duplicate the ammonite collection, which is the core of the paper and the biostratigraphy, at the present time. I had many

conversations with Bairstow during the period 1956 to 1965, and less frequently up to the early 1980s, and quotations from a few of them are given here. This paper is not the same as Bairstow would have written – his account would have had more local details of the outcrops in the bay as they were in the 1920s and 1930s, while the paper now presented is more orientated towards correlation by ammonites, for which his accurately documented sequence in the bay is of major international importance. The comparison that it will afford with rocks of the same age and the sequence of zones and subzones on the Dorset coast is long overdue. Such comparison is too lengthy to be included here – it would involve much collation and reidentification of the many separate collections of Dorset ammonites that now exist, in order to produce a consistent set of determinations, and hence biostratigraphy, that could be compared with the sequence in Yorkshire.

The term Lower Lias is used in the title of this paper and elsewhere as an exact equivalent of Hettangian + Sinemurian + Lower Pliensbachian. This is the sense in which it was widely used and understood by palaeontologists when Bairstow worked in the 1920s and 1930s. Even in those days a different usage by those geologists more interested in lithology and sedimentation led to confusion on occasions: the boundary between Lower and Middle Lias was placed by them at a position that best marked the change from dominantly clayey beds below to dominantly sandy beds above. Such a change in lithology occurs at different horizons in different parts of Britain, so their usage of Lower and Middle Lias did not have an accurate date or age connotation. So much confusion resulted from these disparate usages that the terms are rarely used now-a-days. Lower Lias is retained here, in the sense given above, in deference to Bairstow and the long history of Robin Hood's Bay geology, where it is well understood as being the Sinemurian + Lower Pliensbachian, there being no Hettangian exposed in the bay. In this usage the Middle Lias is exactly equivalent to the Upper Pliensbachian, and the Upper Lias to the Toarcian.

## LESLIE BAIRSTOW

### Biography

Leslie Bairstow (Fig. 3) was born in Halifax, Yorkshire, on 14 August 1907. After attending Ackworth School (1918–22) and Bootham School, York (1922–25), he went to King's College, Cambridge, where he obtained a degree in Geology in 1928. He started research on the Lower Lias of Robin Hood's Bay in the summer of 1928, supported by college scholarships. He had become interested in collecting fossils from the Yorkshire Lias during his school and undergraduate years, and in getting his ammonites identified he came into contact with Dr L.F. Spath at the British Museum (Natural History). It was at Spath's suggestion that he decided to undertake serious research on the Lower Lias of Robin Hood's Bay, and Dr W.D. Lang, also at the Museum, was keen to get another Lower Lias section accurately documented for comparison with his own work on the Lower Lias of Dorset. He also consulted S.S. Buckman, who advised him to record the location of every ammonite he

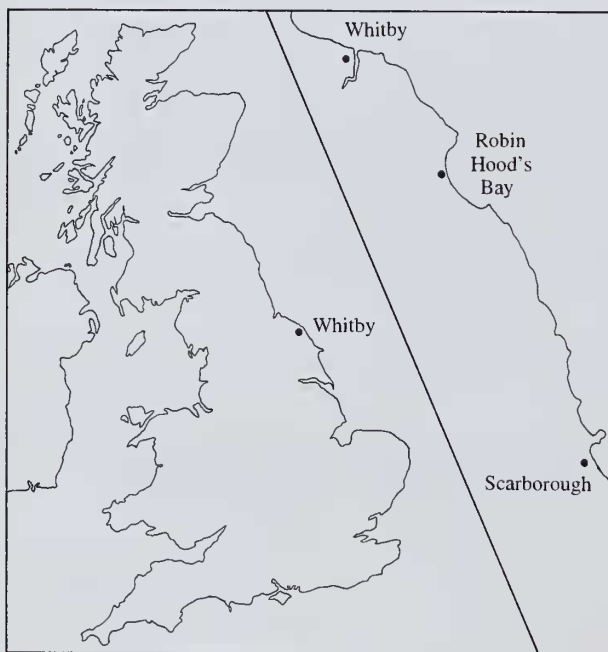


Fig. 1 Map showing the location of Robin Hood's Bay on the north-east coast of England, 10 km south-east of Whitby.



Fig. 2 The Robin Hood's Bay foreshore at low tide, looking north-west from the top of Ravenscar (above Peak) at the south-eastern end of the bay. Robin Hood's Bay town is immediately above the foreshore in the centre-right of the photograph. M.K. Howarth photograph, 28 September 1999.

collected with sufficient accuracy to enable the sequences of ammonite 'hemerae' to be compared at the north-western and south-eastern ends of Robin Hood's Bay. Initially the project was intended to be a thesis for a higher degree at Cambridge University, but the detailed mapping, bed-by-bed description and collecting during 1928–1930 were submitted as a dissertation in support of a fellowship application at King's College in late 1930. This was not successful, and Bairstow was preparing for a second application in 1931, when the offer of a permanent post at The Natural History Museum in South Kensington (then the British Museum (Natural History)), with the opportunity to continue work indefinitely on the Lower Lias of Robin Hood's Bay, appealed to him more than a fellowship at Cambridge of six years duration. In fact, during his early years at the Museum he was elected to a three-year visiting Fellowship at King's College in 1932–35. He started at the Museum in October 1931, and although initially put in charge of fossil echinoderms and later Coleoidea (including belemnites), he was able to continue work on Robin Hood's Bay until his retirement in June 1965. He continued to work at the Museum until 1985, when he moved to Todmorden, Yorkshire, where he died on 10 August 1995.

The meticulous attention to detail that Bairstow lavished on the description, collecting and mapping of the Lower Lias of Robin Hood's Bay, made it unlikely that he would produce a final description with which he would be satisfied. It is fortunate, therefore, that for the Cambridge fellowship dissertation of 1930 he produced a finished manuscript version of the map and a stratigraphical description of the whole succession, which are the basis of the present paper. His most useful collecting occurred during the period 1928–34, and work during the following 40 years did not greatly enhance that original burst of activity. His ammonite collection of about 2,360

specimens is housed in The Natural History Museum, and is a prime record of the sequence of ammonite faunas for the upper two-thirds of the Lower Lias. Such a collection would be difficult to repeat today, because so many of the accessible ammonites have been removed from the Bay. Bairstow conducted field parties to the Bay for the 18th International Geological Congress in 1948 and the William Smith Jurassic Symposium in 1969, and gave brief summaries of the zonal sequence and his bed numbering in the guide books for those meetings (Bairstow, 1948, 1969). Apart from a summary in a guide to the fossils of the Scarborough district (Bairstow, 1953), he left no other published account.

The geological map of Robin Hood's Bay, the description of the stratigraphy and basic biostratigraphy formed the first half of his dissertation for the fellowship at King's College, Cambridge, in 1930. The second half of that dissertation consisted of a description of the Lower Lias belemnites of Robin Hood's Bay, and included an assessment of the 19 specific names proposed by Simpson (1855: 22–31; 1884: 47–54) and partly revised by Phillips (1863–1909), for belemnites from the bay. This part of his work was also destined never to be published, but it did give Bairstow an interest in belemnites and related groups, which led to him being put in charge of fossil Coleoidea at the Natural History Museum. In fact, he did much valuable investigation into the early generic nomenclature of fossil Coleoidea, especially the non-belemnite groups, and his detailed notes were passed on first to Dr J.A. Jeletzky, then to later *Treatise* authors, for incorporation in the Coleoid volume of the *Treatise on Invertebrate Paleontology* (not yet published). In these and other matters, especially the geology of Robin Hood's Bay and general identification of specimens sent to the Museum, colleagues found him helpful and were always enlightened by his views. He had a long



Fig. 3 Leslie Bairstow, aged 46; taken from a group photograph of the Palaeontology Department, the Natural History Museum, 1954.

association with the Palaeontographical Society, first as Treasurer for the years 1948 to 1955, then as Vice President from 1966 until 1969, and he was a Trustee of that Society for several years during the same period. [Other biographies on Bairstow can be found in the obituary notices published by the Geological Society (Howarth, 1996) and King's College, Cambridge (Annual Report, October 1996: 27–29).]

### Bairstow's unpublished work

The originals of the unfinished and unpublished manuscripts left by Bairstow will be deposited in the Earth Sciences Library of The Natural History Museum, London. They can be divided into three main parts, which will now be described in sequence:

1. The geological map of Robin Hood's Bay.
2. The stratigraphical description of the Lower Lias.
3. His collection of ammonites and other fossils, and his list of the determinations of the ammonites.

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## GEOLOGICAL MAPS

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Bairstow drew his geological map of Robin Hood's Bay in 1928–30 and the top copy formed part of his fellowship submission, now preserved in the archives of King's College, Cambridge. The map was drawn at a scale of 1:2500, and consists of eight sheets, each measuring 320 × 343 mm. Bairstow took (and variously modified) a

few geographical lines from the 1:2500 sheets of the Ordnance Survey: these were mainly the top and bottom of the cliffs, some paths and field boundaries at the top of the cliffs, a few roads and prominent buildings, and the line of low tide mark. The latter is the low tide mark of ordinary tides on Ordnance Survey maps (ie. approximately half way between low water mark of spring and neap tides), but Bairstow modified the line to be that of low water mark of spring tides, when the maximum amount of rock is exposed on the foreshore. On some low lying areas low water of spring tides exposes much larger areas of rock than ordinary or neap tides, eg. the area occupied by beds 505–530 north of Robin Hood's Bay town.

Before submission to King's College, Bairstow made machine copies of his map, which he kept throughout his working life and they form the basis of the maps reproduced here. These copies differ from the original maps only in Bairstow's addition of 'datum lines' for locating the ammonites he collected (see the account of his ammonite collection, p. 117 below). I considered the possibility of reproducing Bairstow's original maps in the King's College archives, but the small size of the lettering of the bed numbers, the colour, thinness and lack of sufficient boldness of some of the lines, and logistical difficulties of reproducing maps that are larger than A3 (in one direction), were all against direct reproduction of the originals. After consideration of scale and legibility at the final printed size, it was decided to copy the maps at a different scale, and to divide them into the five sheets (see Fig. 4) that give a better division of the outcrops in Robin Hood's Bay than the original eight maps. Tracing was done with great care, so that the geological lines on the resulting maps reproduced here as Figs 5, 6, 8, 11 and 15 are as close as possible to the lines originally drawn by Bairstow. No alterations were made, and in those parts that were checked, such as the seaward edge of outcrops opposite the mouth of Mill Beck, south of Stoupe Beck, and in Wine Haven, the maps appear to be still accurate, 70 years after they were drawn.

Bairstow did not, however, include the lowest and highest beds on his map: the lowest bed he mapped was the seaward edge of bed 422, Low Balk, though he collected ammonites from lower beds down to bed 421.1. The outcrops of beds 418–421, seaward of Low Balk, were added to the map of Fig. 11 from observations made at the lowest spring tide of the year on 9 September 1991, when they were easily accessible. Similarly, at the top of the succession, the highest bed mapped by Bairstow was bed 590.3, on the south side of Bulmer Steel Hole, even though this is 250 m south of Castle Chamber, which is usually taken as marking the northern boundary of the bay. The higher beds northwards past Castle Chamber and up to the boundary between the Lower and Upper Pliensbachian (ie. the Lower/Middle Lias boundary) were also added to the map of Fig. 5 in September 1991. Thus, the mapping was completed between the lowest bed exposed by the lowest spring tides and the upper boundary of the Lower Pliensbachian. The five large-scale maps are printed here at a scale of 1:5315.

**Map 1** (Fig. 5) is the northernmost map and starts from the highest beds outside the bay to the north-west at the junction with the Upper Pliensbachian. The main geographical feature is the cave of Castle Chamber, where the hard shelly sandstones of beds 599 and 601.1 form the floor and roof of the cave. The outcrop is fairly narrow along the whole of this east facing part of the bay, and is subject to aggressive wave action that results in relatively clean rock surfaces and good exposures.

**Map 2** (Fig. 6) covers the whole sweep of the scars north and south of Robin Hood's Bay town, from the ironstone shales at the top of the map, down through the softer, pyritous shales opposite Dungeon Hole and Ground Wyke (Fig. 7), to the hard siliceous shales that form prominent scars opposite Robin Hood's Bay town. These are Landing

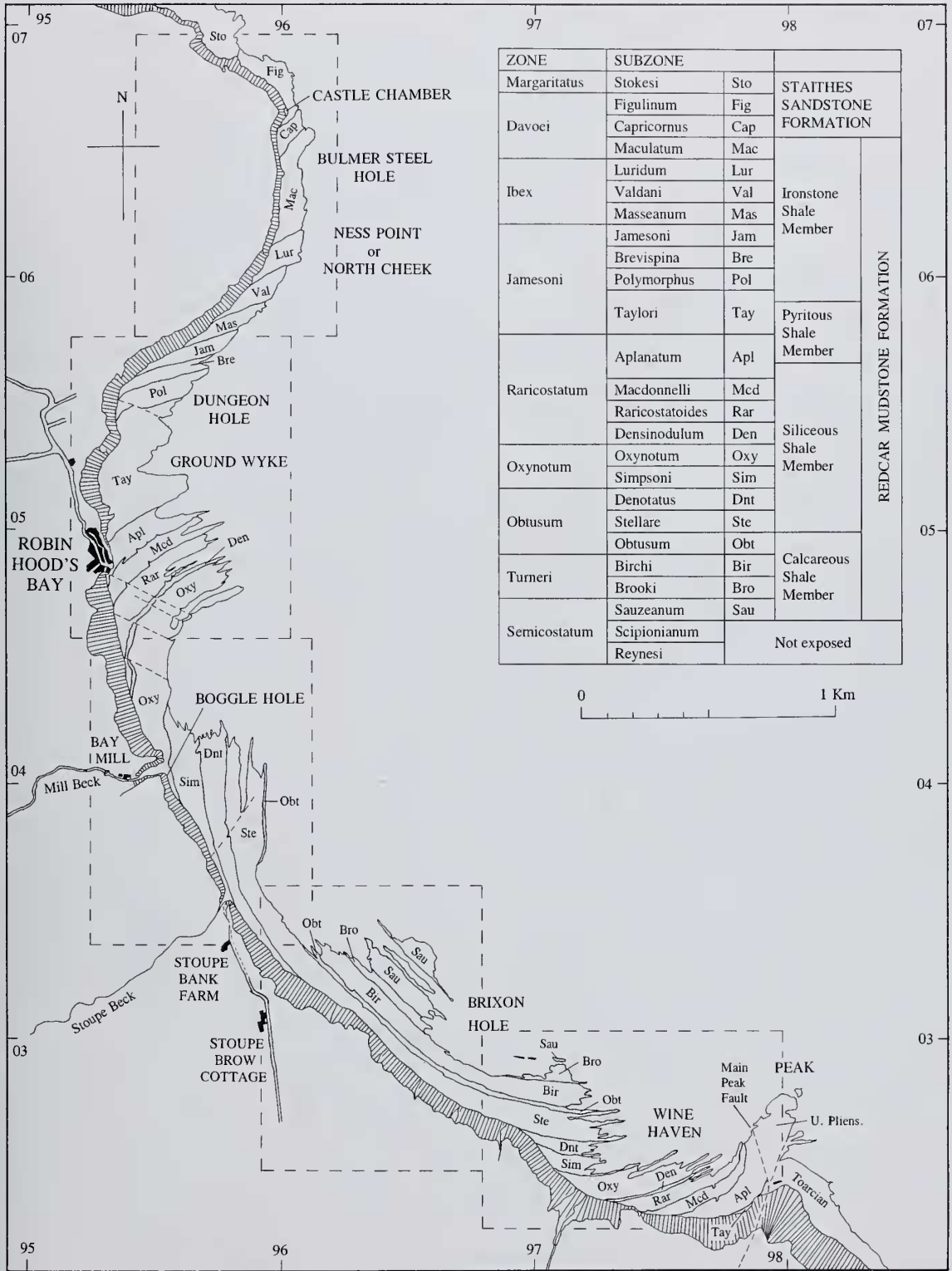


Fig. 4 Summary geological map of the foreshore in Robin Hood's Bay, showing the main geographical features. The geological divisions shown are the subzones, and the areas covered by the five main maps of Figs 5, 6, 8, 11 and 15 are indicated by the rectangles of dashes. The cliff is indicated by vertical lines showing approximately the steepest direction of the face. The table containing the key to the subzones is a summary of Table 1.

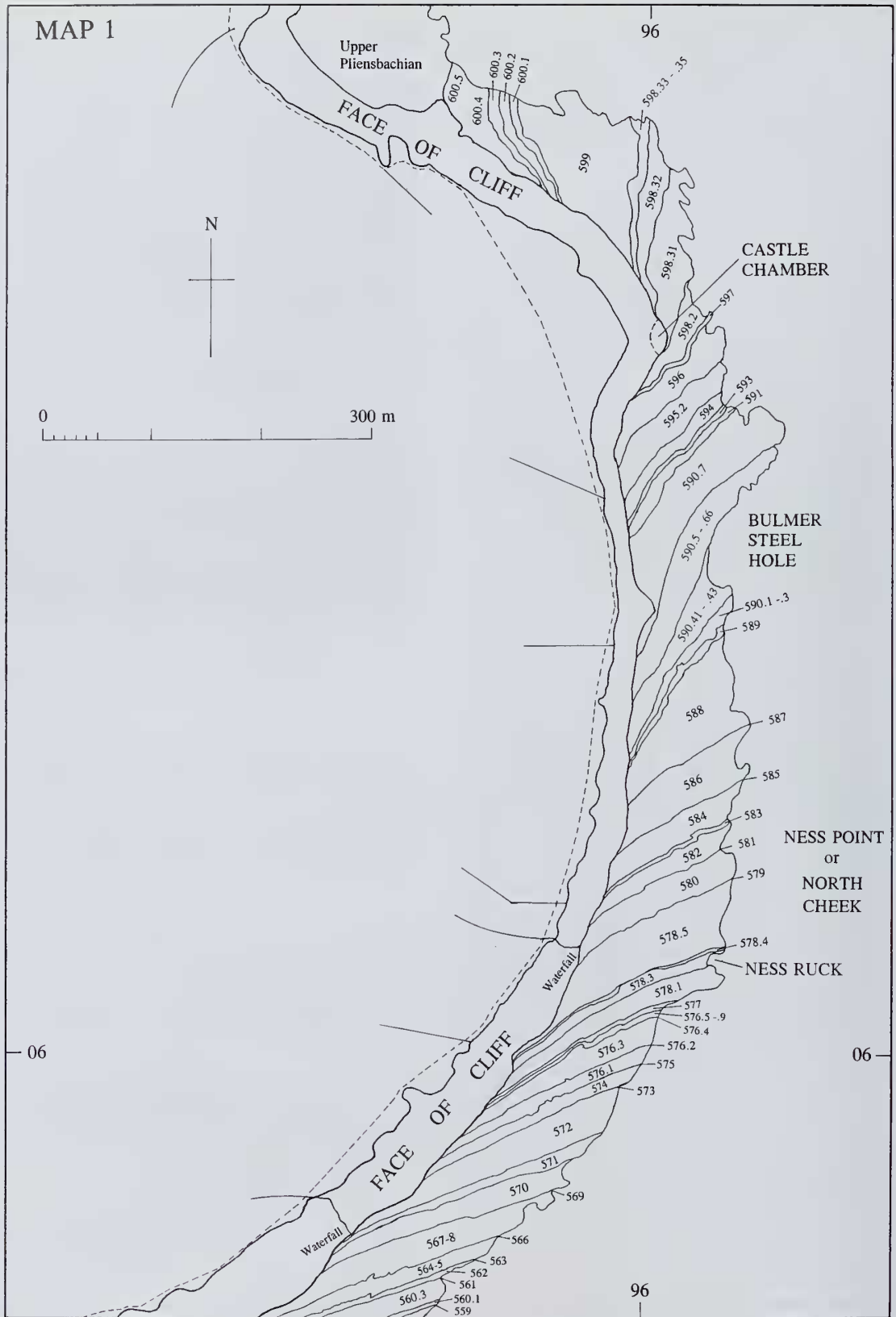


Fig. 5 Map 1, the northernmost part of Robin Hood's Bay, showing the outcrops up to the north-west corner of the bay round to the junction with the Upper Pliensbachian (Middle Lias).

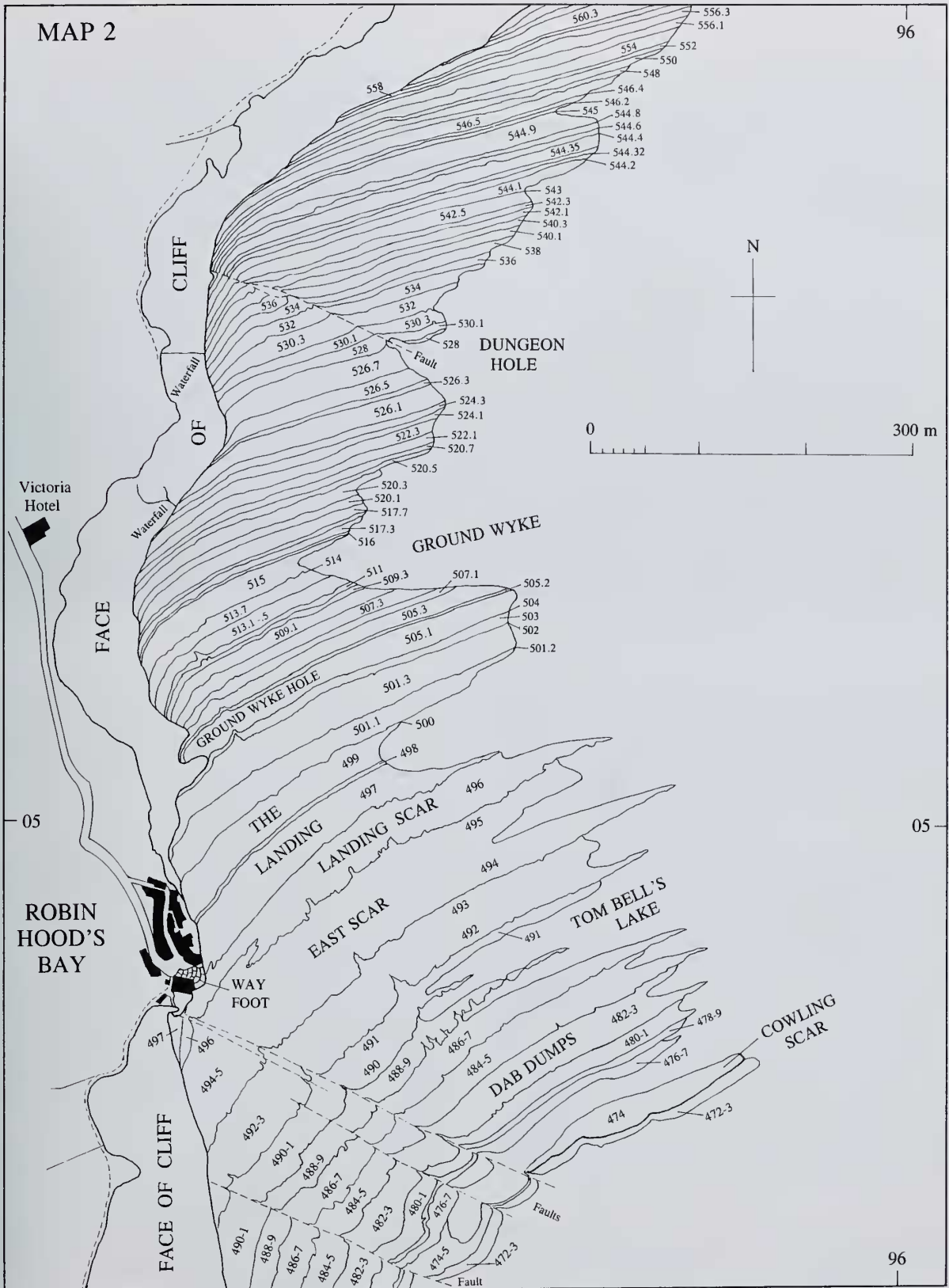


Fig. 6 Map 2, showing outcrops down to the bottom of the Lower Pliensbachian and into the top of the Upper Sinemurian in the rock scars southwards past Robin Hood's Bay town.



**Fig. 7** The foreshore at low tide north of Robin Hood's Bay town. L. Bairstow photograph, 1952, taken from the top of the cliff near the northern edge of Fig. 6. The rock outcrops can be seen to have been relatively clean and free of algae and beach deposits at this time.

Scar! (bed 496) and East Scar (bed 494) opposite the town, and Cowling Scar (bed 474, Double Band) farther out to sea near the bottom edge of the map. The relatively soft beds of the Pyritous Shales around Ground Wyke are the wettest and lowest (relative to sea level) exposed part of the foreshore in the bay, where there is now little or poor rock exposure owing the seaweed, barnacle and mussel bed cover.

**Map 3** (Fig. 8) shows an interesting entity of outcrops around the mouth of Mill Beck, the cliffs that make up 'The Nab', and the major rock scars on the foreshore to the east. There are three prominent scars here – Low Scar, Middle Scar and High Scar, being the hard, calcified silty shales of beds 447, 449 and 455 respectively. Also notable on this map are Tinkler's Stone and Strickland's Dumps, north of the mouth of Stoupe Beck, and both are named on the larger scale Ordnance Survey maps. Tinkler's Stone lies on bed 462 and is a boulder of very hard grey-brown massive limestone, of undetermined origin, but not derived from the Lower Lias. Strickland's Dumps are small, but relatively deep, excavated pools in the dip slope of beds 455.1 and 455.2. The area around Bay Mill and The Nab is shown on a larger scale in Fig. 9. High tides penetrate well into the mouth of Mill Beck between The Nab and the road on the south side of the beck, and sometimes large masses of dead algae partly block or divert the outflow of Mill Beck. However, when the mouth

and bed of Mill Beck are clear of algae, the underlying beds can be seen from bed 475 at the mouth of the beck, past Bay Mill and up to bed 494 in front of the weir. They were mapped by Bairstow as shown on Fig. 9 in an amount of detail that is too great to be shown clearly on the main map. The face of The Nab, with some individual beds identified, is shown in Fig. 10.

**Map 4** (Fig. 11) features the foreshore north-east of Peter White Cliff where there are exposures down to the lowest beds in Robin Hood's Bay (Fig. 12). At low tides the scars of Low Balk (bed 422; see Fig. 13) and the slightly less conspicuous Pseudo Low Balk (bed 424.2) are prominent rock platforms, both of which can normally be reached only by wading through the shallow channels between beds 424 and 425 and along the middle part of bed 422.2, which never dry out, even at the lowest spring tides. Bed 447 forms a long scarp face across the whole width of the map in front of Peter White Cliff (Fig. 14). On the Ordnance Survey maps, the name High Scar is used for two different beds: one for this bed 447 in front of Peter White Cliff, the other for bed 455 east of Mill Beck. So bed 447 forms both Low Scar east of Mill Beck and the Ordnance Survey's 'High scar' at Peter White Cliff. In view of the possible confusion, the latter use of 'High Scar' is not perpetuated here.

**Map 5** (Fig. 15) reaches the south-east corner of the bay, where the Lower Lias succession is truncated by the Peak Fault complex. The Main Peak Fault has a downthrow to the east and a large lateral movement, resulting in Upper Pliensbachian and Toarcian beds on the east abutting the top beds of the Sinemurian and bottom beds of the Lower Pliensbachian on the west. There is a narrow zone of severely shattered beds immediately west of the fault, and minor faults and cracks for some distance farther west. The highest bed exposed on the rock platforms below the cliffs is bed 501.1, the

<sup>1</sup>'Scar' is a term frequently used in descriptions of Yorkshire coast geology for rock outcrops on the foreshore, which are usually below (but may sometimes be above) the level reached by normal high tides. In Robin Hood's Bay several scars are given formal names on some larger scale maps of the Ordnance Survey, and a few others are newly named in this paper. Such scars are formed by, or at least topped by, single beds of hard rock, and all are intertidal in Robin Hood's Bay.



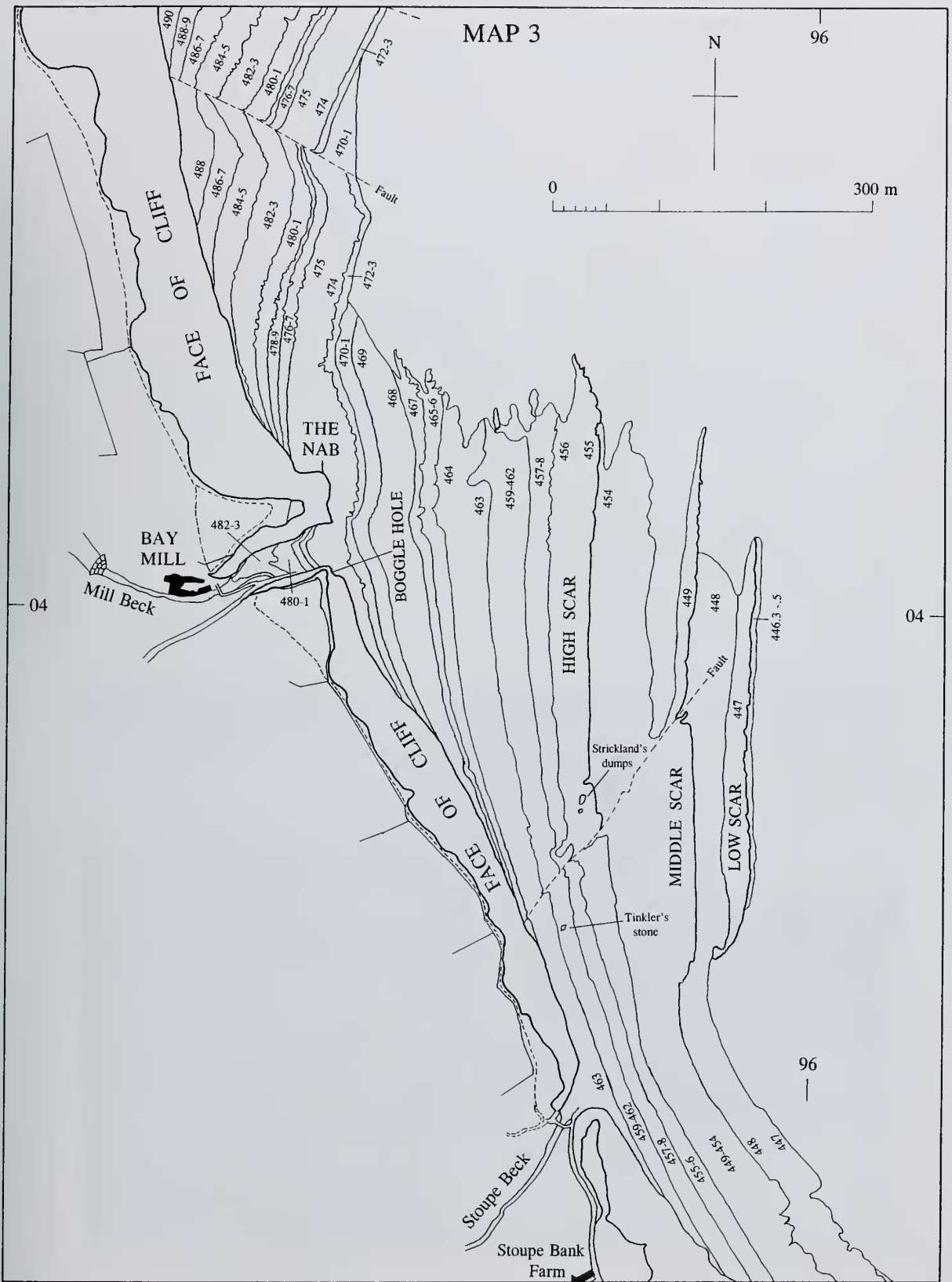


Fig. 8 Map 3, the middle map of the bay, showing the prominent scars on the foreshore east of The Nab and the mouth of Mill Beck, down to the mouth of Stoupe Beck at the bottom of the map.

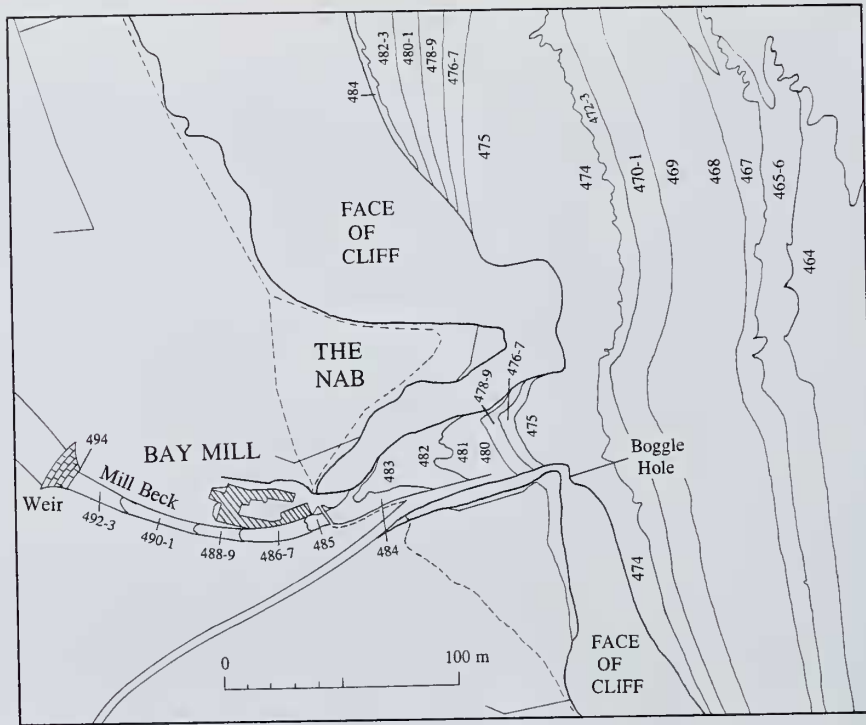


Fig. 9 Details of the outcrops of beds 475–494 in the bed of Mill Beck from the mouth of the beck up to the weir west of Bay Mill.



Fig. 10 The seaward face of The Nab immediately north of the mouth of Mill Beck. M.K. Howarth photograph, 11 September 1991. The beds here are the middle part of the Siliceous Shale Member and belong to the Oxynotum to basal *Raricostatoides* Subzones; the main beds are identified on the right hand side of the photograph.

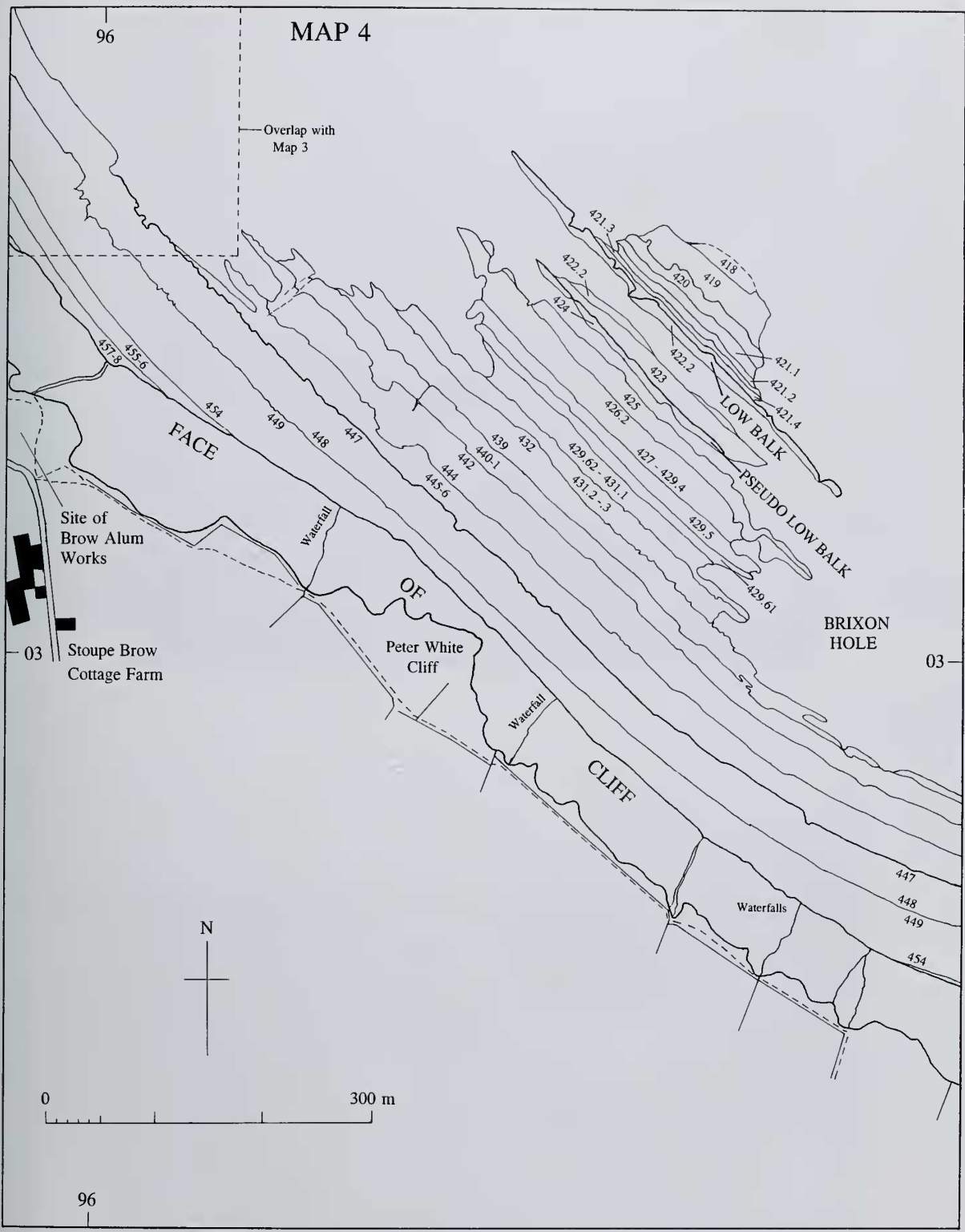


Fig. 11 Map 4, showing outcrops down to the lowest beds exposed in the bay north-east of Peter White Cliff.



**Fig. 12** Oblique aerial view of the foreshore in front of Peter White Cliff at low tide. Air Ministry photograph, 10 October 1938, formerly Crown Copyright. The line of Low Balk (bed 422.2) is the lowest bed visible farthest from the cliff (see Fig. 13), and the long outcrop of the prominent bed 447 can be seen just below the cliff (see Fig. 14).



**Fig. 13** Low Balk (bed 422.2) at low water of spring tide, almost the farthest accessible point north-east of Peter White Cliff. M.K. Howarth photograph, 10 September 1991.



Fig. 14 The prominent hard calcified shale of bed 447 in front of Peter White cliff. M.K. Howarth photograph, 10 September 1991.

lowest bed of the Lower Pliensbachian. The most prominent bed on the map is bed 474, Double Band, which forms Billet Scar (see Fig. 16). The narrow excavation through beds 476–486 known as The Dock, was originally made for fishing and smuggling purposes.

## GEOLOGICAL STRUCTURE OF ROBIN HOOD'S BAY

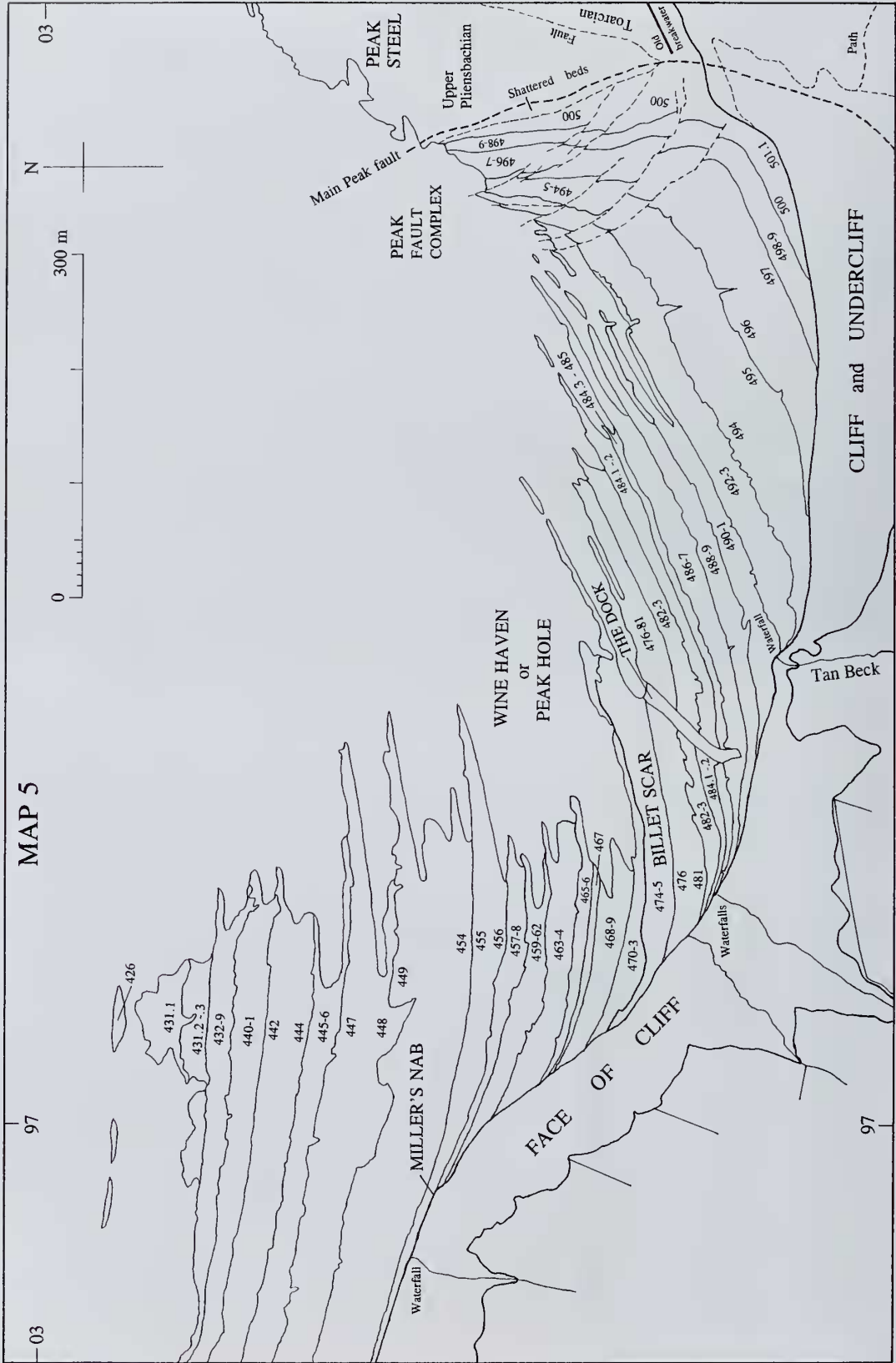
The pattern of the outcrops on the foreshore of the bay as seen in Fig. 4 is determined by the structure of the rocks (Fig. 17). That structure was first alluded to by Tate & Blake (1876: 27, 196) who described Robin Hood's Bay as 'a complete inlier . . . in the form of a mound, dipping in all directions from the centre . . . the centre of elevation beneath the sea, nearly opposite the centre of the bay'. In the Geological Survey memoir, Fox-Strangways & Barrow (1915: 3, 115) referred to the Lias as 'curving over in a gentle arch or anticline'. Versey (1939: pl. 15) plotted the contours of the base of the Grey Limestone (=Scarborough Formation; Lower Bajocian) over a wide area and showed that around the southern and western sides of Robin Hood's Bay they formed the outer part of a north-west to south-east elongated dome. According to Versey (1939) the dome was produced by tectonic movements probably in the late Pliocene. Kent (1974: 25, 26) and de Boer (1974: 281) accepted the date of formation of the dome as later than the mid-Tertiary Alpine movements and probably Pliocene.

The central part of the Robin Hood's Bay dome can be defined by

the outcrops of the Lower Lias on the foreshore of the bay. Fig. 17 shows contours on the outcrop at 10 m bed-thickness intervals, with the 0 m contour starting at the top of bed 422.2, Low Balk. Because the outcrop on the foreshore is essentially flat, the contours approximate closely to strike lines, and they form the pattern of a dome, with a NW to SE axis of elongation in approximately the position shown on the figure. The dip of the beds is at right angles to each contour line away from the centre of the dome. In the northern part of the bay the beds dip NW, and from the 50 m to the 150 m contours the average distance between adjacent contours is 128 m; this gives an average dip of  $4.5^\circ$  for the beds. Between the 20 m and 40 m contours the beds dip to the west, while the lowest beds between the 0 m and 20 m contours dip between west and south at an average of  $3.2^\circ$ . In the south-east corner of the bay near the Peak Fault the beds curve round to dip south-easterly. The Peak Fault throws down on its eastern side and has a lateral movement of several kilometres. Its northern continuation across Robin Hood's Bay, passing close to the shore at the northern end of the bay, is shown on Fig. 17 in accordance with data on the latest map of the British Geological Survey that includes off-shore geology (British Geological Survey, 1995, Tyne Tees, sheet  $54^\circ\text{N}-02^\circ\text{W}$ , 1:250,000, solid geology).

## STRATIGRAPHICAL SUCCESSION

Bairstow drew up a description of the succession in Robin Hood's Bay in 1928–30 and the detailed sequence of beds formed an



**Fig. 15** Map 5, showing the outcrops of Sinemurian and basal Pliensbachian beds in the south-eastern end of the bay, up to their junction with the Peak Fault, which throws them against Upper Pliensbachian and Toarcian to the east.



Fig. 16 The foreshore at low tide in Wine Haven looking eastwards towards Peak and the bottom of the cliff below Ravenscar. L. Bairstow photograph, 1929 or 1930. This view looks along the prominent outcrop of Billet Scar (bed 474) in the middle of the photograph, and 'The Dock' crosses the beds obliquely to the right.

important part of his fellowship submission to King' College. He kept carbon copies of the 85 typed pages of the sequence, and during subsequent years up to 1975 he made alterations, additions and notes on the originals until the final size of the manuscript was about 230 pages. Many alterations were made to the bed numbering, especially at the top, and to the bed thicknesses and details of the lithology, none of which were fully finalized at the time of his fellowship submission. This manuscript is the basis for the much edited version of the stratigraphical succession given below, where as much of the lithological description as necessary has been retained to describe and identify individual beds in the sequence. Bairstow measured bed thicknesses on both the foreshore scars and in the cliffs in order to arrive at figures he considered accurate, and his measurements in feet and inches have been converted to metric units for this paper.

The lithostratigraphical divisions given in the succession below are not those of Bairstow. They are based on more recent work described below in a separate section. Similarly, the zone and subzone divisions given in the succession are based on revisions of the identifications of all Bairstow's ammonites, also as described in a separate section. Table 1 shows a detailed correlation between the

zones and subzones, the bed numbers and the lithostratigraphical divisions.

### Bed numbers

Bairstow started his detailed description of the beds in 1928 by giving the bed number 500 to the nodules that form the northern boundary of The Landing at Bay Town, and worked up and down the succession from that level. That bed number was selected because he did not know what his lowest and highest numbers would be, and also to 'prevent confusion with the numbers [1-132] given by Lang to Lower Lias beds of similar age on the Dorset coast'. After several changes to his various schemes, especially in the top part of the succession, he finalized his numbering with bed 418 as the horizon exposed at the lowest level reached by spring tides in the bay, and bed 601 as the highest he described in the Staithe Sandstone Formation just beyond the northern end of the bay. In various places he subdivided individual beds by giving numbers after a decimal point (eg. beds 485.1, 485.2, 485.3), and a few beds were subdivided to two places of decimals (eg. beds 464.31, 464.32, 464.33). In bed 590,

STAGE	ZONE	SUBZONE	m	BED NO				
U. Pliensbachian	Margaritatus	Stokesi (part)		600.6-601.2	STAITHES SANDSTONE FORMATION			
Lower Pliensbachian	Davoei 32.63 m	Figulinum	9.70	596.2-600.5			Ironstone Shale Member 62.73 m	REDCAR MUDSTONE FORMATION, 151 m
		Capricornus	3.04	591-596.1				
		Maculatum	19.89	581-590.7				
	Ibex 20.39 m	Luridum	7.24	578.1-580				
		Valdani	7.66	571-577				
		Masseanum	5.49	560.3-570				
	Jamesoni 44.46 m	Jamesoni	5.66	550-560.3	Pyritous Shale Member, 26.18 m			
		Brevispina	3.72	544.6-549				
		Polymorphus	7.05	538-544.5				
		Taylori	28.03	527-537 501.1-526.7				
Upper Sinemurian	Raricostatum 17.26 m	Aplanatum	5.57	497-500 496	Siliceous Shale Member 38.74 m			
		Macdonnelli	4.48	494-495.7				
		Raricostatoides	6.21	488-493.5				
		Densinodulum	1.00	486.3-487				
	Oxynotum 14.91 m	Oxynotum	9.19	472.1-486.2				
		Simpsoni	5.72	463-471				
	Obtusum 12.45 m	Denotatus	3.37	455.2-462				
		Stellare	7.37	447-455.1				
		Obtusum	1.71	446.31-446.5				
	Lower Sinemurian (part)	Turneri 7.75 m	Birchi	5.89		433.3-446.2	Calcareous Shale Member 23.35 m exposed	
Brooki			1.86	429.7-433.2				
Semicostatum 13.89 m		Sauzeanum	13.89	418-429.64				
		Scipionianum		Not exposed				
		Reynesi						

**Table 1** Summary of the bed numbers used in Robin Hood's Bay, and their grouping into zones and subzones (including thicknesses), and members and formations, showing the detailed correlation between biostratigraphical and lithostratigraphical divisions.

however, he used three places of decimals (eg. bed 590.433) and in bed 598 he used four places of decimals (eg. bed 598.4322). Three and four places of decimals are considered here to be too cumbersome to be acceptable, so they have all been replaced in this description with the minimum amount of renumbering necessary to achieve single and double decimal numbering in beds 590 and 598. Unfortunately, it was not possible to replace all the double decimal numbering in the succession, because there are more than 9 divisions in beds 429, 495, 544 and 590, and to replace them would have involved renumbering the whole succession. This was not practicable in view of the large number of entries of the original bed numbers on specimen labels, index cards and original manuscripts and maps. It should be noted, however, that the subdivisions that Bairstow used for bed 600 are not in a decimal system like those in all the lower beds – subdivisions of bed 600 use the 13 suffix numbers 1–13 after the decimal point; as these are at the top of the succession extending out of Robin Hood's Bay to the north, they are retained here without alteration.

## DETAILED SUCCESSION IN ROBIN HOOD'S BAY

In the following detailed succession records of all the ammonites and nautiloids in Bairstow's collection are included for each bed; the first number in brackets following each species is the total number of specimens, and is followed by their registration numbers, then by a reference to any specimens figured here; in a few cases the number of registration numbers quoted is less than the total number of specimens recorded, because specimens were lost, destroyed, poorly preserved, uncollectable (but observed by Bairstow), or too numerous to be worth registering all of them. The thickness of each bed is given in the right hand column in metres (m).

Specimen register numbers are identified here and in the remainder of the paper by the following prefixes: C. and CA – The Natural History Museum, London; GSM – British Geological Survey (Geological Survey Museum), Keyworth, Nottinghamshire; OUM – Oxford University Museum; SM – Sedgwick Museum, Cambridge; WM – Whitby Museum, Yorkshire.



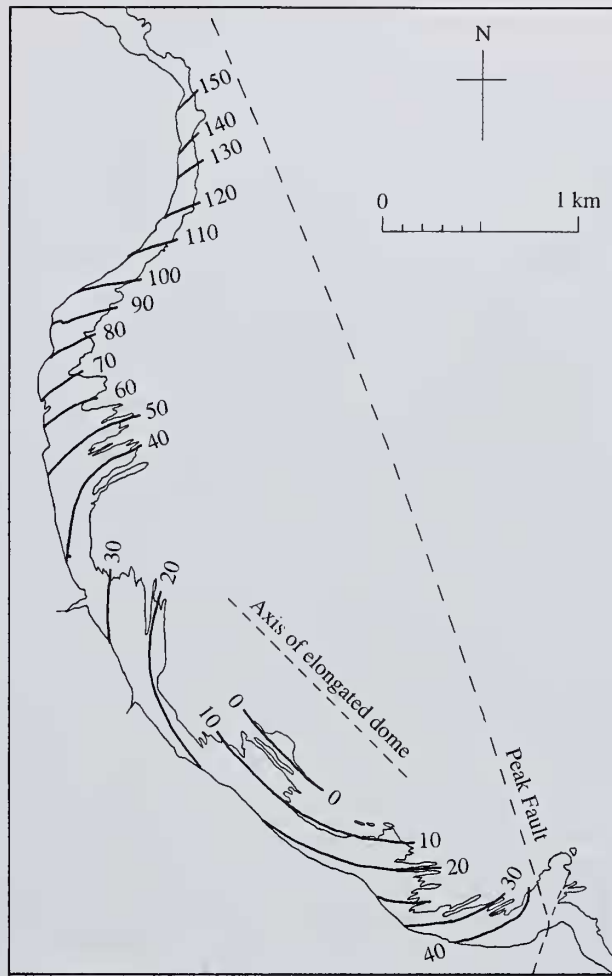


Fig. 17 Map showing contours at 10 m bed thickness intervals in the Lower Lias on the foreshore of Robin Hood's Bay, from which the elongated dome geological structure can be deduced. The only geographical features shown are the line of the base of the cliff and the low tide mark. See text for further explanation.

STAITHES SANDSTONE FORMATION (PART)

Zone of *Amaltheus margaritatus*  
 Subzone of *Amaltheus stokesi* (lower part)

Bed no.		m
601.2	Sandstone, soft, micaceous, laminated .....	0.66
601.1	Sandstone, hard, shelly in parts; many <i>Gryphaea</i> sp.; forms the roof of Castle Chamber at north-west end of Robin Hood's Bay .....	0.81
600.13	Sandstone, soft, silty .....	0.33
600.12	Shale, silty .....	0.38
600.11	Limestone nodules .....	0.10
600.10	Shale, silty .....	0.08
600.9	Shale, sandy .....	0.38
600.8	Shale, silty, with horizon of limestone nodules near top .....	0.53
	<i>Amaltheus stokesi</i> (J. Sowerby) 0.3 m above base (1; CA 4605)	
600.7	Shale, sandy, laminated; forms the most conspicuous positive feature between floor and roof of Castle Chamber .....	0.25
600.6	Flat limestone nodules .....	0.13
	<i>Amaltheus stokesi</i> (J. Sowerby) (1; MKH Coll, lost).	

Zone of *Productylioceras davoei*  
Subzone of *Aegoceras (Oistoceras) figulinum*

600.5	Shale, silty, pale grey .....	0.36
600.4	Limestone nodules (= bed v of Howarth, 1955: 155) .....	0.06
	<i>Aegoceras (Oistoceras) figulinum</i> (Simpson) (11; SM J35968, SM J44776-85).	
600.3	Shale, silty .....	0.91
600.2	Limestone, sideritic, forming a continuous bed (= bed iii of Howarth, 1955: 155) .....	0.18
	<i>Aegoceras (Oistoceras) angulatum</i> (Quenstedt) (9; SM J44790, CA 4595-4602).	
600.1	Shale, silty .....	0.15
599	Sandstone, flaggy, with ripple marks and oyster bands; the top surface forms the floor of Castle Chamber (= bed i of Howarth, 1955: 155) .....	1.42
	<i>Aegoceras (Oistoceras) angulatum</i> (Quenstedt) (1; SM J44789)	
598.35	Shale, silty, laminated .....	0.33
598.34	Limestone nodules .....	0.08
598.33	Shale, silty, laminated .....	1.00
598.32	Limestone, grey, weathering yellow; forms continuous tabular bed .....	0.10
598.31	Shale, silty, soft, but harder near top .....	2.79
598.2	Shale, silty, hard; forms a conspicuous feature in the cliff and on the scar .....	0.15
598.1	Shale, silty, soft, darker than the two beds above; occasional sideritic mudstone nodules in middle and upper part .....	0.67
	<i>Aegoceras (Oistoceras) sinuosiforme</i> Spath (5; C.38930, C.39556, C.39579, CA 4594; Pl. 7, fig. 14).	
597	Limestone nodules .....	0.13
	<i>Aegoceras (Oistoceras) sinuosiforme</i> Spath (42; C.39398, C.39418-36 [C.39421/22 and C. 39429/30 are single specimens], C.39499-39502, C.39505-07, C.39561, C.39568-77, CA 4588-93).	
596.3	Shale, silty, with 0.09 m thick limestone nodules, especially in a band 0.3m below the top .....	1.22
	<i>Aegoceras (Oistoceras) sinuosiforme</i> Spath (28; C.39396-97, C.39399-39417, C.39437-38, C.39504, C.39549, C.39559, CA 4586-87), <i>Liparoceras (L.) divaricosta</i> (Trueman) (1; C.39455; Pl. 8, fig. 1).	
596.2	Hard, calcified shale, with occasional sideritic mudstone nodules .....	0.15
	<i>Aegoceras (Oistoceras) sinuosiforme</i> Spath (18; C.39503, C.39508-10, C.39560, C.39562-67, C.39578, CA 4580-85).	

Subzone of *Aegoceras (A.) capricornus*

596.1	Shale, soft; occasional calcareous mudstone nodules .....	0.85
595.2	Shale, silty, lower half soft, upper half harder; some lenses of oysters .....	0.56
595.1	Scattered calcareous mudstone nodules in hard silty shale .....	0.10
594	Shale, silty, with a few calcareous mudstone nodules .....	0.61
	<i>Aegoceras (A.) lataecosta</i> (J. de C. Sowerby) (1, lost), <i>Aegoceras (A.)</i> sp. indet. (10; CA 4579).	
593	Sideritic mudstone nodules; conspicuous on the scars at Bulmer Steel Hole .....	0.13
	<i>Aegoceras (A.) artigyrus</i> (Brown) (4; CA 4604).	
592	Shale, silty, laminated with some hard bands; a few sideritic mudstone nodules .....	0.61
591	The Oyster Bed. Hard, silty shale, with flat sideritic mudstone nodules; many oysters and other bivalves .....	0.18
	<i>Aegoceras (A.) lataecosta</i> (J. de C. Sowerby) (1; C.39395).	

REDCAR MUDSTONE FORMATION

IRONSTONE SHALE MEMBER

Subzone of *Aegoceras (A.) maculatum*

590.7	Shale, silty .....	1.42
590.66	Spherical sideritic mudstone nodules .....	0.10
590.65	Shale, silty, with scattered sideritic mudstone nodules .....	0.23
590.64	Sideritic mudstone nodules .....	0.08
590.63	Shale, silty, with scattered sideritic mudstone nodules near the base .....	0.20
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (8; C.38881, C.38886-90, C.38893, CA 4578), <i>Aegoceras (A.) maculatum</i> (Young & Bird) var. <i>leckenbyi</i> Spath (1; C.38880).	
590.62	Shale, silty .....	0.41
590.61	Shale, silty, with many sideritic mudstone nodules .....	0.46
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (8; C.38882-85, C.38891-92, C.38894, C.38896; Pl. 7, fig. 13).	
590.5	Shale, silty .....	1.30
590.43	Shale, silty, with a few sideritic mudstone nodules near the top .....	0.23
590.42	Calcareous mudstone nodules .....	0.08
590.41	Shale, silty, with a few sideritic mudstone nodules near the base .....	0.20
590.3	Shale, silty, with occasional very large (up to 1 m diameter) sideritic mudstone nodules 0.5-1.5 m below the top; seen on the scar on the south side of Bulmer Steel Hole .....	3.58

590.2	Hard silty shale, with many small sideritic mudstone nodules .....	0.41
590.1	Shale, silty, with occasional sideritic mudstone nodules .....	0.51
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (7; C.38895, CA 4573-77), ? <i>Androgynoceras</i> sp. indet. (1; CA 4603).	
589	Large sideritic mudstone nodules; a strongly marked band crossing the shore south of Bulmer Steel Hole .....	0.15
588	Shale, silty; one very large sideritic mudstone nodule 1 m below top .....	4.95
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (5; C.39136, C.38878-79, CA 4571-72), <i>Androgynoceras heterogenes</i> (Young & Bird) (1; C.39136), <i>Liparoceras (L.)</i> sp. indet. (2; CA 4562-63).	
587	Flat septarian sideritic mudstone nodules, some with domed upper surfaces .....	0.13
586	Shale, silty .....	2.29
585	Flat septarian sideritic mudstone nodules, some with domed upper surfaces, and sometimes forming a continuous bed ....	0.13
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (1; C.38877).	
584	Shale, silty .....	1.45
	? <i>Lytoceras</i> sp. indet. (1; CA 2795), <i>Aegoceras (A.) maculatum</i> (Young & Bird) (2; C.38876, CA 4570).	
583.2	Shale, with scattered sideritic and calcareous mudstone nodules .....	0.08
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (2; C.38871-72), <i>Aegoceras (A.) maculatum</i> (Young & Bird) var. <i>atavum</i> Spath (2; C.38873-74; Pl. 7, fig. 8), <i>Androgynoceras heterogenes</i> (Young & Bird) (1; C.38875).	
583.1	Continuous bed of sideritic mudstone .....	0.08
582	Shale, silty, with small scattered spherical sideritic mudstone nodules 0.25 m below top .....	1.27
	<i>Liparoceras (L.)</i> cf. <i>naptonense</i> Spath (1; C.39140), ? <i>Aegoceras</i> s.l. sp. indet. (1; not registered).	
581	Flat sideritic mudstone nodules .....	0.15
	<i>Aegoceras (A.) maculatum</i> (Young & Bird) (2; C.41307, CA 4569; Pl. 7, fig. 12).	

Zone of *Tragophylloceras ibex*  
Subzone of *Aegoceras (Beaniceras) luridum*

580	Shale .....	1.30
	<i>Aegoceras (Beaniceras)</i> cf. <i>luridum</i> (Simpson) (1; CA 4568), <i>Liparoceras (L.)</i> cf. <i>naptonense</i> Spath (1; C.39141).	
579	Flat sideritic mudstone nodules .....	0.15
	<i>Liparoceras (L.)</i> sp. indet. (1; lost).	
578.5	Shale .....	3.40
	<i>Aegoceras (Beaniceras) luridum</i> (Simpson) (6; CA 4565-67), <i>Liparoceras (L.)</i> sp. indet. (1; CA 4561), <i>Lytoceras fimbriatum</i> (J. Sowerby) (1; lost); many large <i>Inoceramus</i> .	
578.4	Sideritic shale, with many large (0.6 m diameter, or up to 0.5 m × 1.2 m) flat, septarian, sideritic mudstone nodules; forms a conspicuous bed on the scar just north of Ness Ruck; occasional logs of fossil wood .....	0.23
	<i>Lytoceras fimbriatum</i> (J. Sowerby) (8; CA 2787-94).	
578.3	Shale .....	0.76
	<i>Lytoceras fimbriatum</i> (J. Sowerby) (2; CA 2785-86).	
578.2	Shale, sideritic, with scattered sideritic mudstone nodules .....	0.08
	<i>Lytoceras fimbriatum</i> (J. Sowerby) (3; CA 2782-84).	
578.1	Shale, grey, with a paler and harder middle band; contains several pieces of fossil wood .....	1.32
	<i>Aegoceras (Beaniceras) luridum</i> (Simpson) (1; CA 4564).	

Subzone of *Acanthopleuroceras valdani*

577	Sideritic shale, with occasional sideritic mudstone nodules; crosses the scar to reach low tide mark at Ness Ruck .....	0.13
	<i>Liparoceras (L.)</i> cf. <i>heptangulare</i> (Young & Bird) (1; CA 4560).	
576.9	Shale .....	0.18
576.8	Scattered sideritic mudstone nodules in shale .....	0.08
576.7	Shale .....	0.18
576.6	Scattered sideritic mudstone nodules in shale .....	0.08
	<i>Lytoceras fimbriatum</i> (J. Sowerby) (3; CA 2779-81).	
576.5	Shale .....	0.30
576.4	Scattered flat sideritic mudstone nodules in shale .....	0.05
	<i>Lytoceras fimbriatum</i> (J. Sowerby) (1; CA 2778; Pl. 1, fig. 3).	
576.3	Shale; contains fossil wood .....	1.17
576.2	Widely scattered sideritic mudstone nodules in shale .....	0.10
576.1	Shale .....	1.02
575	Sideritic mudstone nodules, sometimes septarian .....	0.15
	<i>Liparoceras (L.) heptangulare</i> (Young & Bird) (1; CA 4559), <i>Lytoceras fimbriatum</i> (J. Sowerby) (3; CA 2775-77).	
574	Shale; contains fossil wood .....	0.74
573	Sideritic mudstone nodules .....	0.08
572	Shale .....	2.59

571	Shale, with many scattered oval sideritic mudstone nodules up to 0.15m thick .....	0.81
	<i>Liparoceras (L.) heptangulare</i> (Young & Bird) (1; C.39137), <i>Lytoceras fimbriatum</i> (J. Sowerby) (1; CA 2774).	

Subzone of *Tropidoceras masseanum*

570	Shale, with occasional sideritic mudstone nodules that contain gastropods and poorly preserved Crustacea .....	1.73
	<i>Lytoceras fimbriatum</i> (J. Sowerby) (3; CA 2771-73).	
569	Continuous bed of sideritic mudstone; outcrops in a gully on the scars, and forms a conspicuous datum line in the cliff .....	0.08
	<i>Tragophylloceras loscombi</i> (J. Sowerby) (2; CA 2761-62).	
568	Shale, in 7 or 8 pale and dark bands .....	1.68
	<i>Lytoceras</i> sp. indet. near top of bed (1; lost); <i>Tropidoceras futtereri</i> Spath near base of bed (1; CA 4545; Pl. 7, fig. 11); <i>Tropidoceras masseanum</i> (d'Orbigny) var. <i>rotundum</i> (Futterer) at boundary of beds 567 and 568 (11; CA 4546-55).	
567	Shale, hard and silty; forms a slight feature on the scar .....	0.15
566	Shale .....	0.28
	<i>Liparoceras (L.)</i> sp. indet. (1; lost).	
565	Shale, hard and silty; forms a slight feature on the scar .....	0.08
564	Shale, with harder silty bands at the base and the middle; the higher silty band contains occasional sideritic mudstone nodules .....	0.56
	<i>Liparoceras (L.)</i> sp. indet. (1; lost).	
563	Sideritic mudstone nodules; contains large logs of fossil wood .....	0.08
562	Shale, with occasional sideritic mudstone nodules .....	0.69
	<i>Tropidoceras</i> sp. indet. (3; CA 4556-58), <i>Liparoceras (L.) cheltiense</i> (Murchison) (2; C.39138-39).	
561	Flat sideritic mudstone nodules .....	0.08
	<i>Tropidoceras</i> sp. indet. or ? <i>Uptonia</i> cf. <i>jamesoni</i> (J. de C. Sowerby) (2, lost).	
560.3	Shale, with shelly layers (top 0.08 m only) .....	0.08
	<i>Tropidoceras futtereri</i> Spath (1; CA 4544; Pl. 7, fig. 10).	

Zone of *Uptonia jamesoni*  
Subzone of *Uptonia jamesoni*

560.3	Shale, with shelly layers (all below the top 0.08 m) .....	1.32
	<i>Tragophylloceras</i> sp. indet. (1; CA 2770), <i>Polymorphites bronni</i> (Roemer) (7; CA 4224-30; Pl. 7, fig. 5), <i>Uptonia lata</i> (Quenstedt) (1; CA 4538) and <i>Uptonia</i> cf. <i>jamesoni</i> (J. de C. Sowerby) (1; CA 4532).	
560.2	Flat sideritic mudstone nodules; together with bed 559, forms a distinctive pair of nodule beds on the scar .....	0.08
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (1; CA 4531), <i>Polymorphites bronni</i> (Roemer) (2; CA 4222-23).	
560.1	Shale .....	0.15
	<i>Polymorphites bronni</i> (Roemer) (1; CA 4221).	
559	Flat sideritic mudstone nodules .....	0.08
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (1; CA 4530), <i>Uptonia</i> sp. indet. (1; CA 4543), <i>Polymorphites bronni</i> (Roemer) (1; CA 4220).	
558	Shale, with occasional sideritic mudstone nodules at about the middle of the bed .....	0.66
	<i>Uptonia lata</i> (Quenstedt) (5; CA 4533-37), <i>Uptonia</i> sp. indet. (4; CA 4539-42), <i>Polymorphites bronni</i> (Roemer) (16; CA 4204-19), <i>Tragophylloceras</i> sp. indet. (1; CA 2769).	
557	Flat sideritic mudstone nodules; conspicuous in the cliff .....	0.13
	<i>Uptonia</i> cf. <i>jamesoni</i> (J. de C. Sowerby) (1; CA 4529).	
556.3	Shale .....	0.41
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (1; CA 4528).	
556.2	Small spherical, grey, calcareous mudstone nodules, with a few larger flat sideritic mudstone nodules .....	0.08
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (5; CA 4523-27), <i>Polymorphites bronni</i> (Roemer) (3; CA 4201-03).	
556.1	Shale .....	0.71
	<i>Polymorphites bronni</i> (Roemer) (5; CA 4196-4200).	
555	Grey calcareous mudstone nodules mixed with larger sideritic mudstone nodules .....	0.10
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (1; CA 4522), <i>Polymorphites polymorphus</i> (Quenstedt) (2; CA 4316-17; Pl. 7, fig. 3).	
554	Shale .....	0.76
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (2; CA 4520-21), <i>Polymorphites bronni</i> (Roemer) (1; CA 4195), <i>Parinodoceras parinodum</i> (Quenstedt) (1; C.39142).	
553	Flat sideritic mudstone nodules mixed with a few smaller grey calcareous mudstone nodules .....	0.13
	<i>Tragophylloceras</i> sp. indet. (1; CA 2768).	
552	Shale .....	0.33
551	Scattered sideritic mudstone nodules, mixed with smaller grey calcareous mudstone nodules, in shale .....	0.08

	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (5; CA 4515-19).	
550	Shale .....	0.64
	<i>Uptonia jamesoni</i> (J. de C. Sowerby) (5; CA 4510-14), <i>Platypleuroceras</i> cf. <i>brevispina</i> (J. de C. Sowerby) (3; CA 4469-71).	
Subzone of <i>Platypleuroceras brevispina</i>		
549	Flat sideritic mudstone nodules .....	0.10
548	Shale .....	0.36
	<i>Parinodicerias parinodum</i> (Quenstedt) (1; C.39144), <i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (2; CA 4467-68), <i>Radstockicerias</i> sp. indet. (1; CA 3761).	
547	Flat sideritic mudstone nodules .....	0.10
546.5	Shale, with occasional small siderite mudstone nodules in the lower part .....	1.02
	<i>Platypleuroceras aureum</i> (Simpson) (7; CA 4489-95), <i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (2, lost), <i>Polymorphites</i> sp. indet. (1; lost).	
546.4	Scattered sideritic mudstone nodules in shale .....	0.08
	<i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (9; CA 4458-66), <i>Platypleuroceras</i> cf. <i>aureum</i> (Simpson) (1; CA 4488), <i>Tragophylloceras</i> sp. indet. (2; CA 2766-67).	
546.3	Shale .....	0.23
	<i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (11; CA 4448-57), <i>Platypleuroceras aureum</i> (Simpson) (5; CA 4483-87), <i>Platypleuroceras</i> sp. indet. (8; CA 4502-09), <i>Polymorphites trivialis</i> (Simpson) (1; CA 4396), <i>Parinodicerias parinodum</i> (Quenstedt) (1; C.39143).	
546.2	Sideritic mudstone nodules .....	0.08
	<i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (2; CA 4446-47), <i>Platypleuroceras aureum</i> (Simpson) (4; CA 4479-82; Pl. 7, fig. 6), <i>Polymorphites trivialis</i> (Simpson) (1; CA 4395).	
546.1	Shale .....	0.33
	<i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (10; CA 4436-45), <i>Platypleuroceras aureum</i> (Simpson) (6; CA 4473-78), <i>Platypleuroceras</i> sp. indet. (6; CA 4496-4501), <i>Polymorphites trivialis</i> (Simpson) (1; CA 4394).	
545	Flat sideritic mudstone nodules; forms a minor feature in a conspicuous gully on the scar .....	0.15
	<i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (1; CA 4435).	
544	Shale with horizons of nodules, 4.27 m thick; forms a cambered pavement on the scar, bordered on north and south by conspicuous gullies; might be called the 'Polymorphites Bed'.	
544.9	Shale .....	0.71
	<i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (4; CA 4431-34), <i>Polymorphites trivialis</i> (Simpson) (13; CA 4381-93).	
544.8	Scattered flat sideritic mudstone nodules in shale .....	0.10
	<i>Polymorphites trivialis</i> (Simpson) (3; CA 4378-80).	
544.7	Shale .....	0.36
	<i>Platypleuroceras obsoleta</i> (Simpson) (1; CA 4472), <i>Platypleuroceras brevispina</i> (J. de C. Sowerby) (38; CA 4398-4430), <i>Polymorphites trivialis</i> (Simpson) (3; CA 4375-77), <i>Radstockicerias buvigneri</i> (d'Orbigny) (2; CA 3749-50).	
544.6	Flat sideritic mudstone nodules .....	0.10
	<i>Polymorphites trivialis</i> (Simpson) (5; CA 4370-74), <i>Platypleuroceras brevispina</i> (Simpson) (1; CA 4397), <i>Radstockicerias</i> sp. indet. (1; CA 3760).	
Subzone of <i>Polymorphites polymorphus</i>		
544.5	Shale .....	0.33
	<i>Polymorphites trivialis</i> (Simpson) (25; CA 4347-69), <i>Tragophylloceras</i> cf. <i>numismale</i> (Quenstedt) (1; CA 2760).	
544.4	Scattered flat sideritic mudstone nodules in shale .....	0.10
	<i>Polymorphites trivialis</i> (Simpson) (20; CA 4327-46), <i>Radstockicerias sphenonotum</i> (Monke) (2; CA 3757-58; Pl. 5, fig. 4), <i>Radstockicerias</i> sp. indet. (1; CA 3759).	
544.35	Shale, with a few grey calcareous mudstone nodules .....	0.93
	<i>Polymorphites trivialis</i> (Simpson) (11; CA 4319-26; Pl. 7, fig. 7).	
544.34	Small grey calcareous mudstone nodules .....	0.08
544.33	Shale .....	0.32
544.32	Scattered flat sideritic mudstone nodules in shale .....	0.05
544.31	Shale .....	0.40
	<i>Tragophylloceras</i> cf. <i>numismale</i> (Quenstedt) (1; CA 2759).	
544.2	Small grey calcareous mudstone nodules .....	0.08
544.1	Shale, with two horizons of small spherical grey calcareous mudstone nodules .....	0.71
543	Continuous bed of sideritic mudstone; forms the northern boundary of a deep gully .....	0.15
542.5	Shale .....	0.71
	<i>Polymorphites caprarius</i> (Quenstedt) (10; CA 4306-15), <i>Radstockicerias sphenonotum</i> (Monke) (2; CA 3755-56).	

542.4	Scattered small dark grey calcareous mudstone nodules in shale ..... 0.04 <i>Epideroceras</i> sp. indet. (2; CA 4071-72), <i>Polymorphites caprarius</i> (Quenstedt) (15; CA 4292-4305), <i>Polymorphites trivialis</i> (Simpson) (1; CA 4318), <i>Radstockiceras sphenonotum</i> (Monke) (3; CA 3752-54), <i>Tragophylloceras</i> sp. indet. (1; CA 2765).
542.3	Shale ..... 0.33 <i>Polymorphites caprarius</i> (Quenstedt) (6; CA 4286-91).
542.2	Scattered small grey calcareous mudstone nodules in shale ..... 0.04 <i>Polymorphites caprarius</i> (Quenstedt) (5; CA 4281-85).
542.1	Shale ..... 0.58 <i>Polymorphites caprarius</i> (Quenstedt) (8; CA 4273-80), <i>Radstockiceras sphenonotum</i> (Monke) (1; CA 3751).
541	Flat sideritic mudstone nodules ..... 0.08 <i>Polymorphites caprarius</i> (Quenstedt) (4; CA 4269-72), <i>Tragophylloceras numismale</i> (Quenstedt) (1; CA 2758).
540.3	Shale ..... 0.53 <i>Polymorphites caprarius</i> (Quenstedt) (11; CA 4258-68).
540.2	Scattered sideritic mudstone nodules in shale ..... 0.08 <i>Polymorphites caprarius</i> (Quenstedt) (6; CA 4253-57).
540.1	Shale ..... 0.64 <i>Polymorphites caprarius</i> (Quenstedt) (14; CA 4239-52), <i>Hyperderoceras</i> sp. indet. (1; CA 4053).
539	Flat or spherical sideritic mudstone nodules ..... 0.06 <i>Polymorphites caprarius</i> (Quenstedt) (2; CA 4237-38; Pl. 7, fig. 9).
538	Shale ..... 0.81 <i>Polymorphites caprarius</i> (Quenstedt) (6; CA 4231-36).

Subzone of *Phricodoceras taylori*

537	Scattered flat or spherical sideritic mudstone nodules in shale ..... 0.08
536	Shale ..... 0.74
535	Flat or spherical sideritic mudstone nodules ..... 0.08
534	Shale ..... 0.86
533	Flat sideritic mudstone nodules ..... 0.08
532	Shale, with occasional sideritic mudstone nodules ..... 1.22
531	Large flat sideritic mudstone nodules; forms the northern boundary of a gully cut by the Dungeon Hole fault ..... 0.15
530.3	Shale ..... 0.91
530.2	Grey calcareous mudstone nodules ..... 0.05 <i>Phricodoceras cornutum</i> (Simpson) (1; CA 4060).
530.1	Shale ..... 0.81 <i>Gemmellaroceras rutilans</i> (Simpson) (2; CA 4179-80); <i>Pinna folium</i> (Young & Bird) abundant.
529	Widely scattered sideritic mudstone nodules in shale; the lowest nodule bed exposed on the northern side of the Dungeon Hole fault ..... 0.05 <i>Apoderoceras</i> sp. indet. (1; CA 4052).
528	Shale ..... 0.81 <i>Gemmellaroceras</i> sp. indet. (1; CA 4194).
527	Continuous bed of sideritic mudstone; weathers red-brown. and is yellow-brown when broken; a distinctive bed forming a scarp face on the northern boundary of a gully ..... 0.18

PYRITOUS SHALE MEMBER

526.7	Shale, with occasional masses of pyrites, and a few calcareous mudstone nodules ..... 1.57 <i>Apoderoceras</i> sp. indet. (1; CA 4051), <i>Tragophylloceras</i> sp. indet. (1; CA 2764).
526.6	Septarian calcareous mudstone nodules ..... 0.10 <i>Apoderoceras</i> cf. <i>aculeatum</i> (Simpson) (4; CA 4032-35).
526.5	Shale, with occasional masses of pyrites, and a few calcareous mudstone nodules ..... 1.02 <i>Apoderoceras aculeatum</i> (Simpson) (3; CA 4029-31; Pl. 6, fig. 2).
526.4	Calcareous mudstone nodules ..... 0.06 <i>Apoderoceras</i> sp. indet. (2; CA 4049-50).
526.3	Shale, with many masses of pyrites and 'nests' of pyrites with a radiating structure ..... 0.25 <i>Apoderoceras</i> cf. <i>aculeatum</i> (Simpson) (1; CA 4028).
526.2	Calcareous mudstone nodules, some with circular septarian jointing ..... 0.05 <i>Apoderoceras</i> cf. <i>aculeatum</i> (Simpson) (1; CA 4027).
526.1	Shale, with a few 'nests' of pyrites, and some calcareous mudstone nodules, especially in the lower part ..... 1.32 <i>Phricodoceras cornutum</i> (Simpson) (5; CA 4055-59), <i>Gemmellaroceras rutilans</i> (Simpson) (2; CA 4177-78; Pl. 7, fig. 4), <i>Apoderoceras aculeatum</i> (Simpson) (3; CA 4024-26), <i>Apoderoceras</i> sp. indet. (1; CA 4048).
525	Large flat sideritic mudstone nodules, with a very irregular top surface which weathers dark red; a very conspicuous bed crossing the scar south of the Dungeon Hole fault (see bed 520.4) ..... 0.10

	<i>Apoderoceras aculeatum</i> (Simpson) (1; CA 4023), <i>Phricodoceras cornutum</i> (Simpson) (1; CA 4070; Pl. 7, fig. 2).	
524.3	Shale, with a few calcareous or sideritic mudstone nodules, and some 'nests' of pyrites .....	0.51
	<i>Phricodoceras</i> cf. <i>cornutum</i> (Simpson) (1; CA 4054), <i>Apoderoceras aculeatum</i> (Simpson) (1; CA 4022; Pl. 7, fig. 1).	
524.2	Sideritic mudstone nodules; some pyrites .....	0.04
524.1	Shale .....	0.52
	<i>Phricodoceras</i> cf. <i>taylori</i> (J. de C. Sowerby) (1; CA 4069), <i>Apoderoceras</i> sp. indet. (1; CA 4047).	
523	Flat sideritic mudstone nodules .....	0.06
	<i>Apoderoceras aculeatum</i> (Simpson) (1; CA 4021).	
522.3	Shale, with occasional sideritic mudstone nodules .....	0.74
522.2	Flat sideritic mudstone nodules, with circular septarian jointing .....	0.04
522.1	Shale, with occasional sideritic mudstone nodules, some with veins of pyrites, and some 'nests' of pyrites .....	0.66
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (1; CA 4020).	
521	Flat sideritic mudstone nodules, with circular septarian jointing .....	0.05
	<i>Tragophylloceras numismale</i> (Quenstedt) (1; CA 2757).	
520.7	Shale .....	0.48
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (2; CA 4018-19; Pl. 6, fig. 4).	
520.6	Sideritic mudstone nodules .....	0.07
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (2; CA 4016-17), <i>Tragophylloceras</i> cf. <i>numismale</i> (Quenstedt) (1; CA 2756).	
520.5	Shale, with many scattered sideritic mudstone nodules .....	0.36
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (1; CA 4015), <i>Apoderoceras</i> sp. indet. (4; CA 4043-46), <i>Phricodoceras</i> cf. <i>nodosum</i> (Quenstedt) (1; CA 4061), <i>Gemmellaroceras</i> sp. indet. (2; CA 4192-93), <i>Tragophylloceras numismale</i> (Quenstedt) (4; CA 2752-55).	
520.4	Sideritic mudstone nodules, with an irregular top surface; similar to bed 525 about 50 m to the north, but less conspicuous .....	0.10
	<i>Apoderoceras</i> sp. indet. (1; CA 4042).	
520.3	Shale, with many sideritic mudstone nodules .....	0.82
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (1; CA 4014), <i>Tragophylloceras numismale</i> (Quenstedt) (3; CA 2749-51).	
520.2	Sideritic mudstone nodules .....	0.04
	<i>Tragophylloceras numismale</i> (Quenstedt) (1; CA 2748).	
520.1	Shale .....	0.64
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (3; CA 4011-13), <i>Tragophylloceras numismale</i> (Quenstedt) (1; CA 2747).	
519	Clay; forms a conspicuous parting in the cliff, but difficult to recognize on the scars .....	0.03
518	Band of sideritic mudstone, with irregular top surface; outcrops at the foot of a low scarp face that forms the northern side of a gully .....	0.04
517.7	Shale .....	0.66
	<i>Apoderoceras subtriangulare</i> (Young & Bird) (1; CA 4010), <i>Tragophylloceras numismale</i> (Quenstedt) (1; CA 2746).	
517.6	Flat sideritic mudstone nodules .....	0.05
517.5	Shale .....	0.15
517.4	Sideritic mudstone nodules .....	0.05
517.3	Shale .....	0.23
	<i>Gemmellaroceras</i> sp. indet. (2; CA 4190-91).	
517.2	Sideritic mudstone nodules .....	0.05
	<i>Gemmellaroceras</i> sp. indet. (1; CA 4189).	
517.1	Shale .....	0.23
516	Large flat sideritic mudstone nodules .....	0.06
515.7	Shale .....	0.26
515.6	Sideritic mudstone nodules .....	0.08
515.5	Shale .....	0.26
	<i>Tragophylloceras</i> cf. <i>numismale</i> (Quenstedt) (1; CA 2745).	
515.4	Occasional sideritic mudstone nodules in shale .....	0.08
515.3	Shale .....	0.26
515.2	Flat sideritic mudstone nodules .....	0.08
515.1	Shale .....	0.26
514	Flat sideritic mudstone nodules .....	0.04
513.7	Shale .....	0.58
	<i>Apoderoceras</i> sp. indet. (1; CA 4041).	
513.6	Sideritic mudstone nodules .....	0.08
	<i>Apoderoceras</i> sp. indet. (1; CA 4040).	
513.5	Shale, with a few sideritic mudstone nodules .....	0.13
513.4	Sideritic mudstone nodules .....	0.10
513.3	Shale .....	0.08
513.2	Occasional sideritic mudstone nodules in shale .....	0.05

513.1	Shale, with occasional sideritic mudstone nodules ..... <i>Apoderoceras subtriangulare</i> (Young & Bird) (1; CA 4009).	0.33
512	Scattered flat sideritic mudstone nodules in shale .....	0.04
511	Shale ..... <i>Apoderoceras</i> cf. <i>subtriangulare</i> (Young & Bird) (1; CA 4008).	0.25
510	Band of elongated sideritic mudstone nodules up to 1 m long, with two sets of joints at 60° .....	0.04
509.3	Shale .....	0.18
509.2	Scattered sideritic mudstone nodules in shale .....	0.08
509.1	Shale ..... <i>Apoderoceras</i> cf. <i>subtriangulare</i> (Young & Bird) (1; CA 4007), ? <i>Gemmellaroceras</i> sp. indet. (1; CA 4188).	0.53
508	Irregular, septarian sideritic mudstone nodules, set in pale silty shale .....	0.10
507.3	Shale .....	0.43
507.2	Scattered sideritic mudstone nodules in shale ..... <i>Phricodoceras</i> cf. <i>taylori</i> (J. de C. Sowerby) (1; CA 4068).	0.05
507.1	Shale, with a few sideritic mudstone nodules ..... <i>Apoderoceras subtriangulare</i> (Young & Bird) (3; CA 4004-06).	0.30
506	Sideritic mudstone nodules, set in pale silty shale ..... <i>Apoderoceras subtriangulare</i> (Young & Bird) (4; CA 4000-03), <i>Tragophylloceras</i> sp. indet. (1; CA 2763).	0.08
505.3	Shale ..... <i>Apoderoceras subtriangulare</i> (Young & Bird) (2; CA 3998-99).	0.64
505.2	Shale, with many scattered sideritic mudstone nodules ..... <i>Apoderoceras subtriangulare</i> (Young & Bird) (2; CA 3996-97), <i>Radstockiceras buvigneri</i> (d'Orbigny) (1; CA 3748), <i>Tragophylloceras numismale</i> (Quenstedt) (1; CA 2744; Pl. 1, fig. 1).	0.20
505.1	Shale ..... <i>Apoderoceras subtriangulare</i> (Young & Bird) (2; CA 3994-95), <i>Gemmellaroceras tubellum</i> (Simpson) (1; CA 4176), <i>Cenoceras striatum</i> (J. Sowerby) (1; CN 87).	1.30
504	Sideritic mudstone nodules set in pale silty shale ..... <i>Phricodoceras taylori</i> (J. de C. Sowerby) (1; CA 4067), <i>Apoderoceras subtriangulare</i> (Young & Bird) (2; CA 3992-93).	0.08
503	Shale; 0.51 m thick in Wine Haven ..... ? <i>Gemmellaroceras</i> sp. indet. (6; CA 4182-87).	0.41
502	Occasional grey calcareous mudstone nodules, set in pale silty shale ..... <i>Phricodoceras</i> cf. <i>taylori</i> (J. de C. Sowerby) (3; CA 4064-66), <i>Apoderoceras subtriangulare</i> (Young & Bird) (6; CA 3986-91; Pl. 6, fig. 5).	0.08
501.3	Shale ..... <i>Phricodoceras</i> cf. <i>taylori</i> (J. de C. Sowerby) (2; CA 4062-63), <i>Apoderoceras</i> sp. indet. (5; CA 4036-39), <i>Gemmellaroceras</i> sp. indet. (4; CA 4181).	1.52
501.2	Occasional grey calcareous mudstone nodules in shale ..... <i>Apoderoceras</i> cf. <i>subtriangulare</i> (Young & Bird) (3; CA 3983-85), <i>Gemmellaroceras tubellum</i> (Simpson) (63; CA 4113-75).	0.05
501.1	Shale; with calcareous mudstone nodules, 0.05 m thick, at about the middle, which is the highest nodule bed on the foreshore on the west side of the Peak Fault complex in Wine Haven ..... <i>Bifericeras donovani</i> Dommergues & Meister (18; CA 3793-3810; Pl. 8, fig. 3), <i>Apoderoceras subtriangulare</i> (Young & Bird) (3; CA 3980-82; Pl. 5, fig. 8).	1.83
Zone of <i>Echioceras varicostatum</i> Subzone of <i>Paltechioceras aplanatum</i>		
500	Flat sideritic mudstone nodules; forms the north-western boundary of The Landing at Bay Town .....	0.08
499	Shale, with a few large calcareous mudstone nodules; forms the north-western part of the floor of The Landing at Bay Town; 1.83 m thick in Wine Haven ..... <i>Paltechioceras tardecrescens</i> (Hauer) (2; CA 4607-08), <i>Eoderoceras armatum</i> (J. Sowerby) (7; CA 3885-91; Pl. 8, fig. 2), <i>Gleviceras guibalianum</i> (d'Orbigny) (1; CA 4606).	1.57
498	Shale, with numerous septarian sideritic mudstone nodules; runs down the middle of The Landing ..... <i>Paltechioceras tardecrescens</i> (Hauer) (72; CA 3573-3643; Pl. 4, fig. 6), <i>Eoderoceras armatum</i> (J. Sowerby) (8; CA 3878-84), <i>Gemmellaroceras tubellum</i> (Simpson) (15; CA 4098-4112).	0.23
497	Shale, dark grey with 3 paler stripes of silty shale; contains at least one log of fossil wood 2 m long; forms the south- eastern part of the floor of The Landing at Bay Town ..... <i>Paltechioceras tardecrescens</i> (Hauer) (154; CA 3428-3572; Pl. 4, fig. 3), <i>Paltechioceras regustatum</i> (Buckman) (2; CA 3426-27), <i>Eoderoceras armatum</i> (J. Sowerby) (44; CA 3834-77), <i>Gleviceras guibalianum</i> (d'Orbigny) (6; CA 3735-40), <i>Gemmellaroceras tubellum</i> (Simpson) (24; CA 4074-97).	2.29
SILICEOUS SHALE MEMBER		
496	Hard calcified, silty shale; forms the capping to Landing Scar at Bay Town .....	1.40



*Gleviceras guibalianum* (d'Orbigny) (2; CA 3733-34), *Paltechioceras regustatum* (Buckman) (16; CA 3410-25),  
*Paltechioceras* sp. indet. (6; CA 3644-49).

In Wine Haven bed 496 caps a conspicuous scar running from 130 m east of Tan Beck waterfall into the west side of the Peak Fault complex, where it can be divided into:

496c	Hard calcified, silty shale .....	0.28 m
496b	Shale, with a few large sideritic mudstone nodules .....	0.21 m
496a	Hard calcified, silty shale, especially hard near base .....	0.91 m

Subzone of *Leptechioceras macdonnelli*

495.7	Shale .....	0.84
	<i>Gemellaroceras tubellum</i> (Simpson) (1; CA 4073), <i>Leptechioceras</i> cf. <i>macdonnelli</i> (Portlock) (1; CA 3404).	
495.6	Harder shale, with a few sideritic mudstone nodules .....	0.13
	<i>Gleviceras guibalianum</i> (d'Orbigny) (3; CA 3730-32).	
495.5	Shale .....	0.15
	<i>Eoderoceras armatum</i> (J. de C. Sowerby) (1; CA 3833).	
495.4	Harder calcified shale .....	0.15
495.3	Shale .....	0.30
495.2	Hard calcified shale .....	0.36
495.15	Shale .....	0.43
	<i>Eoderoceras armatum</i> (J. de C. Sowerby) (1; CA 3832).	
495.14	Harder shale .....	0.13
495.13	Shale, with rare sideritic mudstone nodules in Wine Haven .....	0.33
	<i>Leptechioceras</i> cf. <i>macdonnelli</i> (Portlock) (1; CA 3403).	
495.12	Harder shale .....	0.13
495.11	Shale .....	0.53
494	Hard calcified, silty shale; forms the capping of East Scar at Bay Town, and forms a well-marked scar in Wine Haven running eastwards from Tan Beck waterfall, where a few sideritic mudstone nodules occur in the top 0.20 m .....	1.00
	<i>Leptechioceras</i> aff. <i>macdonnelli</i> (Portlock) (3; CA 3400-02), <i>Eoderoceras armatum</i> (J. Sowerby) (1; CA 3831), <i>Radstockiceras buvignieri</i> (d'Orbigny) (4; CA 3744-47; Pl. 5, fig. 1).	

Subzone of *Echioceras raricostatoides*

493.5	Shale .....	0.86
	<i>Paltechioceras planum</i> (Trueman & Williams) (1; CA 3409).	
493.4	Hard calcified, silty shale; two 0.08 m partings of softer shale seen in the Wine Haven cliff .....	0.91
	<i>Paltechioceras planum</i> (Trueman & Williams) (3; CA 3406-08).	
493.3	Shale .....	0.38
	<i>Paltechioceras planum</i> (Trueman & Williams) (1; CA 3405).	
493.2	Hard calcified, silty shale; contains a few sideritic mudstone nodules in Wine Haven .....	0.33
	<i>Echioceras intermedium</i> (Trueman & Williams) (5; CA 3383-87), <i>Eoderoceras hastatum</i> (Young & Bird) (4; CA 3892-95; Pl. 6, fig. 3).	
493.1	Shale .....	0.22
492	Hard calcified, silty shale; 0.28 m in Wine Haven; caps a strong scar south of East Scar, and a conspicuous scar in Wine Haven where it passes from cliff to scars at the foot of Tan Beck waterfall .....	0.23
491.3	Shale .....	0.37
491.2	Harder shale .....	0.48
	<i>Echioceras intermedium</i> (Trueman & Williams) (2; CA 3381-82).	
491.1	Shale, with one or two slightly harder bands .....	1.19
	<i>Echioceras raricostatoides</i> Vadasz (1; CA 3399).	
490	Hard calcified, silty shale; forms the highest scar that passes in front of Tan Beck waterfall in Wine Haven; crosses Mill Beck just west of Bay Mill .....	0.18
	<i>Echioceras raricostatoides</i> Vadasz (5; CA 3394-98).	
489	Shale, soft, laminated; 0.88 m in Wine Haven .....	0.91
	<i>Echioceras raricostatoides</i> Vadasz (8; CA 3389-93; Pl. 4, fig. 2).	
488	Hard calcified, silty shale; has a softer central part and is 0.22 m thick in Wine Haven; crosses Mill Beck beside Bay Mill .....	0.15
	<i>Echioceras raricostatoides</i> Vadasz (1; CA 3388), <i>Crucilobiceras densinodulum</i> Buckman (1; CA 3830).	

Subzone of *Crucilobiceras densinodulum*

487	Shale, with two 0.09 m slightly harder bands .....	0.92
	<i>Crucilobiceras densinodulum</i> Buckman (2; CA 3829) in lower part.	

486.3	Hard calcified, silty shale, with many small calcareous mudstone nodules: the 'Crucilobicerias Bed' ..... 0.08 <i>Crucilobicerias densinodulum</i> Buckman (18; CA 3812-28; Pl. 6, fig. 1).	0.08
Zone of <i>Oxynticeras oxynotum</i> Subzone of <i>Oxynticeras oxynotum</i>		
486.2	Shale ..... 0.06 <i>Bifericeras</i> cf. <i>vitreum</i> (Simpson) (1; CA 3811).	0.06
486.1	Hard calcified, silty shale; 0.33 m in Wine Haven, where there is a softer central 0.10m parting ..... 0.25	0.25
485.3	Shale; a few lenticles of calcareous mudstone in Wine Haven ..... 0.55	0.55
485.2	Harder shale; 0.17 m in Wine Haven ..... 0.22 <i>Gleviceras doris</i> (Reynès) (1; CA 3727), <i>Angulaticeras</i> sp. indet. (1; CA 2801).	0.22
485.1	Shale ..... 0.43	0.43
484	Hard calcified, silty shale, with a central parting about 0.09 m thick; similar to, but less conspicuous than, bed 474, the Double Band; 0.56 m thick in Wine Haven ..... 0.44 <i>Gleviceras</i> cf. <i>guibalianum</i> (d'Orbigny) (2; CA 3728-29).	0.44
483.5	Shale ..... 0.13	0.13
483.4	Harder shale ..... 0.46	0.46
483.3	Shale, with a few harder lenticles near the base in Wine Haven ..... 0.43 <i>Oxynticeras</i> sp. indet. (1; CA 3722), ? <i>Gleviceras</i> sp. indet. (1; CA 3743).	0.43
483.2	Harder shale; 0.09 m in Wine Haven ..... 0.48	0.48
483.1	Shale; 0.25 m in Wine Haven ..... 0.18 ? <i>Gleviceras</i> sp. indet. (1; CA 3742), <i>Bifericeras bifer</i> (Quenstedt) (5; CA 3788-92).	0.18
482.5	Hard calcified, silty shale; forms the capping to the main Dab Dumps scar; 0.08 m in Wine Haven ..... 0.10	0.10
482.4	Shale ..... 0.10 ? <i>Gleviceras</i> sp. indet. (1; CA 3741).	0.10
482.3	Hard calcified, silty shale; 0.10 m in Wine Haven ..... 0.08 <i>Oxynticeras</i> sp. indet. (1; CA 3721).	0.08
482.2	Shale; 0.10 m in Wine Haven ..... 0.08	0.08
482.1	Hard calcified, silty shale; caps a fairly prominent scar on Dab Dumps; crosses Mill Beck nearly opposite the foot of Mill Bank where the road reaches the shore ..... 0.13 <i>Oxynticeras</i> sp. indet. (1; CA 3720).	0.13
481	Shale; 0.43 m in Wine Haven ..... 0.38 <i>Oxynticeras oxynotum</i> (Quenstedt) (1; CA 3716; Pl. 4, fig. 4).	0.38
480	Hard calcified, silty shale; 0.89 m in Wine Haven, where the upper half is less hard ..... 0.80 <i>Oxynticeras</i> sp. indet. (2; CA 3718-19).	0.80
479	Shale ..... 0.20 <i>Oxynticeras</i> cf. <i>oxynotum</i> (Quenstedt) (1; CA 3715).	0.20
478	Hard calcified, silty shale ..... 0.14	0.14
477	Shale, with some thin slightly harder bands ..... 0.42	0.42
476	Hard calcified, silty shale; 0.14 m in Wine Haven; crosses Mill Beck just inside the mouth of the valley ..... 0.10 <i>Gleviceras doris</i> (Reynès) (2; CA 3725-26; Pl. 4, fig. 7).	0.10
475.6	Shale, slightly indurated in places ..... 0.13	0.13
475.5	Hard calcified mudstone lenticles ..... 0.02	0.02
475.4	Shale, slightly harder in basal 0.05 m ..... 0.77	0.77
475.3	Blue or red-weathering calcareous mudstone nodules ..... 0.05 <i>Oxynticeras oxynotum</i> (Quenstedt) (1; CA 3714).	0.05
475.2	Shale, slightly harder in top 0.13 m ..... 0.43	0.43
475.1	Harder shale; 0.10 m in Wine Haven ..... 0.08	0.08
474	The Double Band. Hard calcified, silty shale, with a softer central parting, forming a conspicuous double band; caps Cowling Scar in the middle of the bay, forms a terrace in front of Mill Beck Nab and Boggle Hole, and caps Billet Scar in Wine Haven in the south of the bay.	
474.3	Hard calcified, silty shale; 0.25 m in Wine Haven, where there are some patches of pyrites ..... 0.20 ? <i>Paroxynticeras salisburgense</i> (Hauer) (2; CA 3723-24).	0.20
474.2	Shale, softer, only partially calcified ..... 0.08	0.08
474.1	Hard calcified, silty shale ..... 0.15	0.15
473	Shale, soft, but a partially calcified band in the middle ..... 0.25 <i>Oxynticeras</i> sp. indet. (1; lost).	0.25
472.3	Partly calcified shale ..... 0.13	0.13
472.2	Hard calcified, silty shale ..... 0.13	0.13
472.1	Shale, slightly calcified in places ..... 0.61 <i>Oxynticeras oxynotum</i> (Quenstedt) (1; CA 3713).	0.61

Subzone of *Oxynticeras simpsoni*

471	Shale, with occasional calcareous mudstone 'cheese' doggers and masses of pyrites; 0.91 m near Miller's Nab .....	0.86
470	Calcareous mudstone nodules enveloped in cone-in-cone structures, some 'cheese' doggers and a few strings of pyrites ..	0.08
	<i>Gagaticeras exortum</i> (Simpson) (1; CA 3297), <i>Gagaticeras neglectum</i> (Simpson) (35; CA 3348-64), <i>Oxynticeras simpsoni</i> (Simpson) (2; CA 3711-12).	
469	Shale, with scattered calcareous mudstone 'cheese' doggers .....	1.83
468	Shale, with many calcareous mudstone nodules about 0.08 m thick enveloped in cone-in-cone structures, and thin lenticles of shelly limestone .....	0.13
	<i>Gagaticeras exortum</i> (Simpson) (5; CA 3292-96; Pl. 2, fig. 7), <i>Gagaticeras finitimum</i> Blake (3; CA 3306-08), <i>Gagaticeras neglectum</i> (Simpson) (28; CA 3325-47; Pl. 2, fig. 6), <i>Gagaticeras</i> sp. indet. (10; CA 3372-80), <i>Oxynticeras simpsoni</i> (Simpson) (22; CA 3689-3710; Pl. 4, fig. 5), <i>Cenoceras striatus</i> (J. Sowerby) (1; CN 93).	
467	Calcified shale .....	0.10
	<i>Oxynticeras simpsoni</i> (Simpson) (29; CA 3660-88), <i>Gagaticeras exortum</i> (Simpson) (9; CA 3283-91), <i>Gagaticeras finitimum</i> Blake (8; CA 3298-3305), <i>Gagaticeras gagateum</i> (Young & Bird) (2; CA 3309-10), <i>Gagaticeras neglectum</i> (Simpson) (14; CA 3311-24), <i>Gagaticeras</i> sp. indet. (7; CA 3365-71), <i>Palaeoehioceras</i> sp. indet. (3; CA 3280-82).	
466	Shale, with two thin partially calcified bands; 0.48 m thick between Peter White Cliff and Miller's Nab .....	0.57
	<i>Oxynticeras</i> cf. <i>simpsoni</i> (Simpson) (2; CA 3658-59).	
465	Hard sandy and micaceous calcified shale .....	0.08
	<i>Oxynticeras</i> cf. <i>simpsoni</i> (Simpson) (2; CA 3656-57).	
464.33	Shale, with indurated patches and scattered 'cheese' doggers of lenticular limestone up to 0.2 m thick and up to 2.5 m diameter .....	0.39
	<i>Oxynticeras simpsoni</i> (Simpson) (1; CA 3655), <i>Oxynticeras</i> sp. indet. (1; CA 3717), <i>Angulaticeras</i> sp. indet. (1; CA 2800), <i>Cymbites</i> sp. indet. (1; CA 3783).	
464.32	Band of irregularly-shaped limestone nodules in a shale matrix .....	0.35
	<i>Oxynticeras simpsoni</i> (Simpson) (3; CA 3652-54; Pl. 4, fig. 8), <i>Eparietites impendens</i> (Young & Bird) (14; CA 3262-75), <i>Cymbites</i> sp. indet. (1; CA 3782), <i>Cenoceras striatus</i> (J. Sowerby) (1; CN 86).	
464.31	Shale .....	0.10
	<i>Eparietites impendens</i> (Young & Bird) (2; CA 3260-61).	
464.2	Harder calcified shale .....	0.06
464.1	Shale, with scattered calcareous mudstone nodules .....	1.12
	<i>Eparietites impendens</i> (Young & Bird) (13; CA 3248-59), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (1; CA 3776), <i>Angulaticeras</i> sp. indet. (1; CA 2799).	
463	Calcareous mudstone nodules; many <i>Cardinia</i> .....	0.05
	<i>Oxynticeras simpsoni</i> (Simpson) (2; CA 3650-51), <i>Eparietites impendens</i> (Young & Bird) (3; CA 3245-47).	

Zone of *Asteroceras obtusum*Subzone of *Eparietites denotatus*

462	Shale, with occasional sideritic mudstone 'cheese' doggers; 0.91 m thick between Peter White Cliff and Miller's Nab .....	0.97
	<i>Eparietites impendens</i> (Young & Bird) (16; CA 3229-44; Pl. 4, fig. 1), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (7; CA 3769-75), <i>Angulaticeras</i> sp. indet. (2; CA 2797-98). 'Tinkler's Stone' is a boulder of very hard grey-brown massive limestone, not derived from the Lower Lias, resting on bed 462 about 150 m north of the mouth of Stoupe Beck; it measures 1.8 m × 1.3 m × 0.85 m high and weighs about 6000 kg.	
461	Partly calcified shale .....	0.05
	<i>Eparietites impendens</i> (Young & Bird) (3; CA 3226-28; Pl. 1, fig. 6), <i>Angulaticeras</i> sp. indet. (1; CA 2796).	
460	Shale .....	0.29
	<i>Eparietites</i> cf. <i>impendens</i> (Young & Bird) (2; CA 3224-25).	
459	Partly calcified shale, with occasional calcareous mudstone nodules in the lower part .....	0.10
	<i>Eparietites impendens</i> (Young & Bird) (2; CA 3222-23).	
458.3	Shale .....	0.18
	<i>Aegasteroceras crassum</i> Spath (2; CA 3051-52), <i>Aegasteroceras</i> sp. indet. (2; CA 3177-78), <i>Eparietites impendens</i> (Young & Bird) (1; CA 3221), <i>Cymbites</i> sp. indet. (1; CA 3781).	
458.2	Partly calcified shale .....	0.23
	<i>Aegasteroceras crassum</i> Spath (4; CA 3047-50; Pl. 2, fig. 4), <i>Aegasteroceras</i> sp. indet. (1; CA 3176).	
458.1	Shale; with occasional calcareous mudstone nodules .....	0.20
	<i>Aeger laevis</i> (Blake) (Decapod crustacean; Withers, 1933); <i>Aegasteroceras sagittarium</i> (Blake) (4; CA 3172-75).	
457	Calcified shale .....	0.08
	<i>Aegasteroceras sagittarium</i> (Blake) (4; CA 3168-71), <i>Eparietites impendens</i> (Young & Bird) (1; CA 3220).	
456	Shale, with scattered small calcareous mudstone nodules in the lower half .....	0.66
	<i>Aegasteroceras crassum</i> Spath (1; CA 3046), <i>Aegasteroceras sagittarium</i> (Blake) (60; CA 3108-67; Pl. 1, fig. 7), <i>Cymbites</i> sp. indet. (2; CA 3779-80).	

455	Hard calcified shale, with two softer partings; bed 455 caps High Scar north of Stoupe Beck, and it also forms the highest scar in front of Miller's Nab, west of Wine Haven; the dip slope of beds 455.1 and 455.2 is pierced by several small excavated pools known as Strickland's Dumps (after Sir Charles Strickland), 285 m north of the mouth of Stoupe Beck.	
455.5	Hard calcified shale, with occasional small calcareous mudstone nodules near the top ..... 0.15 <i>Aegasteroceras crassum</i> Spath (1; CA 3045), <i>Aegasteroceras sagittarium</i> (Blake) (1; CA 3107), <i>Eparietites bairstowi</i> sp. nov. (2; CA 3218-19; Pl. 2, fig. 8).	
455.4	Shale ..... 0.23 <i>Asteroceras</i> cf. <i>blakei</i> Spath (2; CA 3008-09), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (2; CA 3767-68).	
455.3	Partially calcified shale ..... 0.10 <i>Asteroceras blakei</i> Spath (4; CA 3004-07).	
455.2	Shale ..... 0.13 <i>Asteroceras blakei</i> Spath (1; CA 3003), ? <i>Cymbites</i> sp. indet. (1; CA 3778), <i>Eparietites bairstowi</i> sp. nov. (1; CA 3217; Pl. 3).	

Subzone of *Asteroceras stellare*

455.1	Partially calcified shale ..... 0.10 <i>Aegasteroceras sagittarium</i> (Blake) (4; CA 3103-06), <i>Asteroceras</i> cf. <i>blakei</i> Spath (1; CA 3002).	
454.2	Shale with occasional calcareous mudstone nodules ..... 1.04 <i>Aegasteroceras sagittarium</i> (Blake) (49; CA 3054-3102), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (1; CA 3766).	
454.1	Shale with many small calcareous mudstone nodules; more calcified in lower part ..... 0.10 <i>Promicroceras planicosta</i> (J. Sowerby) (31; C.49425-31, CA 3953-75), <i>Asteroceras blakei</i> Spath (4; CA 2999-3001), <i>Aegasteroceras sagittarium</i> (Blake) (1; CA 3053), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (1; CA 3765).	
453.3	Calcified shale ..... 0.25 <i>Promicroceras planicosta</i> (J. Sowerby) (10; C.49418-21, C.49423-24, CA 3950-51), <i>Xipheroceras</i> sp. indet. (1; C.49422).	
453.2	Shale ..... 0.13 ? <i>Cymbites</i> sp. indet. (1; CA 3777), <i>Promicroceras planicosta</i> (J. Sowerby) (18; C.49406-14, C.49417, CA 3944-49), <i>Xipheroceras</i> sp. indet. (1; C.49405), <i>Asteroceras blakei</i> Spath (3; CA 2996-98).	
453.1	Calcified shale, with many calcareous mudstone nodules ..... 0.08 <i>Promicroceras planicosta</i> (J. Sowerby) (12; C.49402-03, C.49415-16, CA 3936-43), <i>Xipheroceras ziphus</i> (Zieten) (1; C.49404), <i>Asteroceras</i> sp. indet. (4; CA 3040-43), <i>Asteroceras blakei</i> Spath (2; CA 2994-95).	
452	Shale ..... 0.43 <i>Xipheroceras ziphus</i> (Zieten) (2; C.49400-01), <i>Promicroceras planicosta</i> (J. Sowerby) (27; C.49383-99), <i>Asteroceras blakei</i> Spath (12; CA 2982-93; Pl. 2, fig. 2).	
451	Calcified shale, with occasional small calcareous mudstone nodules ..... 0.10 <i>Promicroceras planicosta</i> (J. Sowerby) (158; C.49369-82, CA 3918-35; Pl. 5, fig. 3), <i>Xipheroceras ziphus</i> (Zieten) (2; CA 3784-85; Pl. 5, fig. 5), <i>Xipheroceras</i> sp. indet. (1; C.49368), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (1; CA 3764), <i>Asteroceras stellare</i> (J. Sowerby) (7; CA 3028-34), <i>Asteroceras</i> sp. indet. (2; CA 3038-39).	
450.3	Partially calcified shale; the top 0.3 m of this bed is the lowest horizon present in the cliff; it occurs in the base of Peter White Cliff, and all lower beds outcrop on the wave-cut platform of the foreshore only ..... 0.91	
450.2	Shale, with many calcareous mudstone nodules and a few 'cheese' doggers ..... 0.10 <i>Asteroceras stellare</i> (J. Sowerby) (1; CA 3027).	
450.1	Shale, with some partly calcified lenticles and a few red-weathering 'cheese' doggers ..... 0.82 <i>Asteroceras stellare</i> (J. Sowerby) (2; CA 3025-26), <i>Promicroceras planicosta</i> (J. Sowerby) (1; CA 3917), both species 0.3 m above the base.	
449	Hard calcified silty shale, with well-marked jointing in two directions; forms the capping to Middle Scar between Stoupe Beck and Mill Beck; 0.19 m thick near Miller's Nab ..... 0.15 <i>Asteroceras stellare</i> (J. Sowerby) (7; CA 3018-24), <i>Aegasteroceras crassum</i> Spath (1; CA 3044).	
448.5	Shale; 0.73 m on Miller's Nab scars ..... 0.56 <i>Promicroceras planicosta</i> (J. Sowerby) (2; CA 3915-16), <i>Asteroceras</i> sp. indet. (1; CA 3037).	
448.4	Harder, partially calcified silty shale ..... 0.10 <i>Asteroceras</i> sp. indet. (1; CA 3036).	
448.3	Shale; 0.41 m on Miller's Nab scars ..... 0.33 <i>Asteroceras stellare</i> (J. Sowerby) (1; CA 3017).	
448.2	Grey calcareous mudstone nodules ..... 0.09	
448.1	Shale ..... 1.52 <i>Promicroceras planicosta</i> (J. Sowerby) (3; CA 3912-14), <i>Epophioceras landriotti</i> (d'Orbigny) (2; CA 3277-78), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (1; CA 3763; Pl. 5, fig. 6).	
447	Hard indurated, well-jointed, silty, calcified shale; a very conspicuous bed, forming the capping to Low Scar between Mill Beck and Stoupe Beck, and the capping to the most prominent scar between Stoupe Beck and Miller's Nab ..... 0.56 <i>Asteroceras stellare</i> (J. Sowerby) (1; CA 3016).	

## CALCAREOUS SHALE MEMBER

Subzone of *Asteroceras obtusum*

446.5	Shale, with occasional cone-in-cone enveloped grey calcareous mudstone nodules, especially in a band from 0.10 m to 0.25 m below the top .....	0.56
	<i>Epophioceras landrioti</i> (d'Orbigny) (1; CA 3276), <i>Xipheroceras ziphus</i> (Zieten) (1; C.49360), <i>Cymbites laevigatus</i> (J. de C. Sowerby) (1; CA 3762), <i>Promicroceras planicosta</i> (J. Sowerby) (20; C.49343-59, C.49366-67).	
446.4	Harder, partially calcified shale .....	0.15
	<i>Epophioceras</i> sp. indet. (1; CA 3279), <i>Xipheroceras</i> cf. <i>ziphus</i> (Zieten) (1; C.49337), <i>Promicroceras planicosta</i> (J. Sowerby) (1; C.49338).	
446.33	Shale, with widely scattered calcareous nodules .....	0.25
	<i>Promicroceras planicosta</i> (J. Sowerby) (7; C.49362-65, CA 3909-11), <i>Asteroceras confusum</i> Spath (3; CA 3012-14), <i>Xipheroceras dudressieri</i> (d'Orbigny) (1; C.49336; Pl. 5, fig. 2), <i>Xipheroceras</i> sp. indet. (2; C.49361, CA 3787).	
446.32	Large scattered calcareous nodules in a shale matrix .....	0.15
	<i>Promicroceras capricornoides</i> (Quenstedt) (4; C.49340-42, CA 3908), <i>Asteroceras confusum</i> Spath (2; CA 3010-11; Pl. 1, fig. 4), <i>Asteroceras obtusum</i> (J. Sowerby) (1; CA 3015), <i>Xipheroceras</i> sp. indet. (1; CA 3786).	
446.31	Shale, finely laminated, with occasional strings and masses of pyrites .....	0.60
	<i>Promicroceras capricornoides</i> (Quenstedt) (7; C.49339, CA 3902-07), <i>Asteroceras</i> sp. indet. (1; CA 3035).	

Zone of *Caenisites turneri*Subzone of *Microderoceras birchi*

446.2	Cone-in-cone enveloped calcareous mudstone nodules .....	0.15
446.1	Shale .....	0.30
	<i>Promicroceras capricornoides</i> (Quenstedt) (1; C.49335).	
445	Hard calcified shale .....	0.13
444	Calcareous mudstone nodules .....	0.06
443.3	Shale, with a few calcareous mudstone nodules .....	1.37
	<i>Promicroceras capricornoides</i> (Quenstedt) (10; C.49327-34).	
443.2	Hard calcified shale .....	0.25
	<i>Promicroceras capricornoides</i> (Quenstedt) (1; CA 3901).	
443.1	Grey calcareous mudstone nodules .....	0.05
442.2	Hard partially calcified shale .....	0.48
442.1	Grey crystalline shelly limestone, weathering yellow-brown; lenticular or nodular in some places .....	0.08
441.3	Shale with occasional small calcareous mudstone nodules, especially at the middle of the bed .....	0.30
441.2	Harder calcified shale and shaly limestone .....	0.15
	<i>Microderoceras scoresbyi</i> (Simpson) (1; C.49327).	
441.1	Shale, with occasional calcareous mudstone nodules .....	0.41
440	Grey shaly limestone, weathering yellow-brown .....	0.13
439	Grey calcareous mudstone nodules .....	0.05
438	Shale .....	0.15
437	Harder partially calcified shale .....	0.10
	<i>Promicroceras capricornoides</i> (Quenstedt) (3; C.49323-25).	
436	Shale .....	0.61
	<i>Promicroceras capricornoides</i> (Quenstedt) (13; C.49315-22, CA 3896-3900), <i>Arnioceras</i> sp. indet. (1; CA 2938).	
435	Hard calcified shale and shaly limestone .....	0.15
	<i>Caenisites</i> cf. <i>turneri</i> (J. de C. Sowerby) (2; CA 3211-12), ? <i>Caenisites</i> sp. indet. (4; CA 3213-16), ? <i>Arnioceras</i> sp. indet. (2; CA 2937).	
434	Grey calcareous mudstone nodules .....	0.06
433.3	Shale, with impersistent calcified patches and thin shaly limestones .....	0.91
	<i>Microderoceras birchi</i> (J. Sowerby) (5; C.49314, CA 3976-79; Pl. 5, fig. 7), <i>Caenisites turneri</i> (J. de C. Sowerby) (24; CA 3187-3210; Pl. 2, figs 3, 5), <i>Caenisites brooki</i> (J. Sowerby) (4; CA 3183-86).	

Subzone of *Caenisites brooki*

433.2	Harder calified shale, with limestone lenses .....	0.11
433.1	Shale, with occasional small calcareous mudstone nodules and cone-in-cone structures .....	0.15
432	Grey shaly limestone, weathering yellow-brown, nodular in the lower half, and shelly in places .....	0.10
431.3	Shale, with some thin lenses and patches of shelly limestone, especially in the upper part .....	0.86
	<i>Caenisites brooki</i> (J. Sowerby) (2; CA 3181-82), <i>Arnioceras</i> sp. indet. (1; lost).	
431.2	Hard, grey, shelly limestone, nodular in the lower half; some masses of pyrites .....	0.08
	<i>Caenisites</i> cf. <i>brookii</i> (J. Sowerby) (5; CA 3179-80, 3 lost).	

431.1	Shale, with a few thin lenses of limestone in the upper part .....	0.30
430	Hard, pyritous, shelly, grey limestone, weathering yellow-brown .....	0.08
	<i>Arnioceras</i> sp. indet. (1; lost).	
429.8	Shale, with 0.06 m thick calcareous mudstone nodules in the top half .....	0.15
429.7	Flat lenses of hard, grey, crystalline limestone .....	0.03
Zone of <i>Arnioceras semicostatum</i>		
Subzone of <i>Euagassiceras sauzeanum</i>		
429.64	Grey calcareous mudstone nodules .....	0.05
	<i>Arnioceras semicostatum</i> (Young & Bird) (1; CA 2913), <i>Coroniceras (Arietites) alcinoe</i> (Reynès) (2; CA 2803-04; Pl. 1, fig. 8).	
429.63	Shale, with thin lenses of shaly limestone, especially at the top of the lower third .....	0.61
429.62	Occasional grey calcareous mudstone nodules in shale .....	0.05
	<i>Arnioceras semicostatum</i> (Young & Bird) (4; CA 2909-12).	
429.61	Shale, with small sideritic mudstone nodules, and occasional much larger 'cheese' doggers up to 2 m diameter .....	0.61
	<i>Arnioceras semicostatum</i> (Young & Bird) (2; CA 2907-08).	
429.5	Grey limestone, shaly in places, weathering yellow-brown, with small nodules on its upper surface .....	0.08
429.4	Shale, containing many small grey calcareous mudstone nodules .....	0.08
	<i>Arnioceras semicostatum</i> (Young & Bird) (1; lost).	
429.3	Shale, with very occasional calcareous mudstone nodules .....	0.36
429.2	Thin continuous or nodular grey limestone, shaly in places .....	0.03
429.1	Shale .....	0.18
	<i>Arnioceras obliquecostatum</i> (Zieten) (1; lost), <i>Arnioceras</i> sp. indet. (2; CA 2935-36).	
428	Shale, with lenses or a continuous band of grey shaly limestone in the top third, and calcareous mudstone nodules in the lower third .....	0.15
	<i>Arnioceras semicostatum</i> (Young & Bird) (5; CA 2902-06).	
427.3	Shale .....	0.38
	<i>Arnioceras semicostatum</i> (Young & Bird) (4; CA 2898-2901).	
427.2	Irregular band of hard grey shaly limestone, weathering brown .....	0.15
	<i>Arnioceras semicostatum</i> (Young & Bird) (4; CA 2895-97), <i>Coroniceras (Arietites)</i> sp. indet. (1; CA 2805).	
427.1	Shale, with some lenses of shaly limestone, and a few large 'cheese' doggers of sideritic mudstone .....	0.71
	<i>Arnioceras</i> sp. indet. (1; CA 2934).	
426.2	Hard grey shaly limestone, weathering brown, with a rough top surface; forms a conspicuous scar landward of Pseudo Low Balk (bed 424.2); many <i>Gryphaea</i> .....	0.05
	<i>Coroniceras (Arietites) alcinoe</i> (Reynès) (1; CA 2802), <i>Arnioceras semicostatum</i> (Young & Bird) (10; CA 2885-94), <i>Arnioceras</i> sp. indet. (1; CA 2933).	
426.1	Hard calcified shale, weathering brown .....	0.15
	<i>Arnioceras semicostatum</i> (Young & Bird) (3; CA 2882-84), <i>Euagassiceras</i> sp. indet. (1; CA 2973).	
425.7	Shale, with a few indurated patches .....	0.15
425.6	Grey calcified shale, weathering brown .....	0.11
	<i>Arnioceras semicostatum</i> (Young & Bird) (9; CA 2873-81).	
425.5	Shale; very occasional large calcareous mudstone 'cheese' doggers .....	0.15
	<i>Arnioceras semicostatum</i> (Young & Bird) (16; CA 2857-72), <i>Arnioceras miserabile</i> (Quenstedt) (2; CA 2919-20).	
425.4	Grey calcified shale, weathering brown .....	0.11
	<i>Arnioceras</i> sp. indet. (1; CA 2932).	
425.3	Shale .....	0.15
	<i>Arnioceras</i> sp. indet. (1; CA 2931).	
425.2	Grey calcified shale, weathering brown .....	0.11
	<i>Arnioceras</i> sp. indet. (1; CA 2930).	
425.1	Shale, with a few indurated patches .....	0.52
	<i>Euagassiceras</i> sp. indet. (2; CA 2971-72), <i>Arnioceras</i> sp. indet. (11; CA 2921-29).	
424.3	Calcified shale, harder in the upper half; occasional small calcareous mudstone nodules .....	0.61
	<i>Euagassiceras</i> sp. indet. (3; CA 2968-70), <i>Arnioceras semicostatum</i> (Young & Bird) (18; CA 2839-56), <i>Arnioceras miserabile</i> (Quenstedt) (3; CA 2916-18), <i>Coroniceras (Arietites) alcinoe</i> (Reynès) (1; C.41310).	
424.2	Shale, partially calcified in the top half; this middle division of bed 424 forms the scar 'Pseudo Low Balk' which emerges immediately landward of Low Balk (bed 422.2) .....	0.30
	<i>Arnioceras semicostatum</i> (Young & Bird) (10; CA 2829-38; Pl. 1, fig. 2), <i>Arnioceras miserabile</i> (Quenstedt) (2; CA 2914-15).	
424.1	Shale, partially calcified near the top .....	0.61
423	Shale, no subdivisions observed .....	1.58
422.2	Hard blue-grey flaggy limestone, weathering brown, with a rough top surface; slightly micaceous; forms the capping of	

	the very conspicuous scar Low Balk .....	0.10
	<i>Euagassicerias resupinatum</i> (Simpson) (21; CA 2942-62; Pl. I, fig. 5).	
422.1	Hard grey micaceous calcified shale, weathering brown .....	0.30
	<i>Euagassicerias resupinatum</i> (Simpson) (1; CA 2941).	
421.4	Hard partially calcified shale, micaceous and with strings of pyrites in places; a few harder calcified lenses near the top ..	0.91
	<i>Arnioceras semicostatum</i> (Young & Bird) (31; CA 2806-28, CA 2974-81), <i>Euagassicerias resupinatum</i> (Simpson) (2; CA 2939-40), <i>Euagassicerias</i> sp. indet. (5; CA 2963-67).	
421.3	Shale; forms a terrace on the scar due to a harder band at the top .....	0.46
421.2	Shale; forms a terrace due to a harder band at the top .....	0.69
	<i>Euagassicerias</i> sp. indet. (1; lost).	
421.1	Shale; forms a terrace due to a harder band at the top .....	0.91
	<i>Euagassicerias</i> sp. indet. (2; lost), <i>Arnioceras</i> sp. indet. (1; lost).	
420	Hard grey flaggy limestone passing down into grey shale; slightly micaceous and pyritous; full of bivalves in places; forms a dip slope 25 m wide and a scarp face 0.13 m high .....	1.75
419	Hard grey calcified shale, slightly micaceous; dip slope 1 m wide, and scarp face 0.13 m high .....	0.13
418	Hard grey partially calcified shale; slightly micaceous; forms a terrace 4 m wide, ending seaward in a scarp face 0.46 m high; the lowest bed exposed at low water of the lowest spring tides .....	0.60

## LITHOSTRATIGRAPHY

The Lower Lias of Robin Hood's Bay is 163.74 m thick and belongs to the Redcar Mudstone and the lower part of the Staithes Sandstone Formations. These names were introduced as formations by Powell (1984: 53) and Howard (1985: 262), and details of their definitions were given by Cox *et al.* (1998: 35, 39). Fig. 18 is a complete vertical section of the succession of the Lower Lias in Robin Hood's Bay, showing the changes in lithology, the lithological divisions and the main features of significance formed by the harder beds, some of which have received formal names; bed thicknesses are drawn to scale on this figure, giving a visual indication of the relative thicknesses of the subzones and lithostratigraphical divisions.

### Staithes Sandstone Formation (beds 591–601.2 and higher)

Consists of sandstones, that are mid to pale grey, fine to medium-grained, micaceous, with grey siltstone bands and some beds of silty shales; nodules of argillaceous limestone occur in the shales and are occasionally sideritic; there is much bioturbation, cross-bedding and ripple marked bedding, especially in the sandstones.

The type area is in Robin Hood's Bay. The formation is somewhat transitional from the underlying Redcar Mudstone Formation, but a convenient marker bed that defines the lower boundary just south of Castle Chamber is bed 591, the Oyster Bed, which is a hard, calcified, silty shale or argillaceous sandstone, containing many oysters and other fossils. Above this level the amounts of silt and sand are higher than lower in the sequence and hard and soft sandstones are frequent. The formation has no subdivisions and extends up into the lower half of the Upper Pliensbachian. The Lower Pliensbachian (ie. *Capricornus* and *Figulinum* Subzones) part of the formation is 12.74 m thick.

### Redcar Mudstone Formation (beds 418–590; 151 m thick)

Consists of mudstones and shales, grey, soft and well-bedded, but some beds are indurated due to calcification, and there are some harder siltstones; thin beds of shelly limestone occur in the lower part, and nodules of calcareous or sideritic mudstone occur, especially

in the upper part; pyritized nodules or irregular aggregations of iron pyrites occur at some horizons.

Although the name is derived from the Lower Lias exposures at Redcar to the north-west, and the lower boundary is defined in the BGS Felixkirk Borehole (Cox *et al.* 1998: 35), the type section consists of the whole sequence exposed in Robin Hood's Bay below the base of the Staithes Sandstone Formation. Here the lithology is more argillaceous than in the Staithes Sandstone Formation, though different parts are variously more calcareous, siliceous, pyritous or ferruginous, and they form the basis of the following four members:

4. Ironstone Shale Member.
3. Pyritous Shale Member.
2. Siliceous Shale Member.
1. Calcareous Shale Member.

These members were introduced as 'Shales' by Buckman (1915: 61) for lithological divisions in Robin Hood's Bay below the 'Sandy Series' (= Staithes Sandstone Formation), and he based them on groups of the ammonite zones that he applied to the succession. His zones can be linked to beds in his detailed sections, but they are not the same as the ammonite zones recognized now, and in any case it is not satisfactory to base lithological divisions on the ranges of palaeontological zones. No formal definitions have been given to these divisions, though Hesselbo & Jenkyns (1995: 114–135) applied them informally to the succession, and placed boundaries between them at appropriate levels in the succession, all of which are followed here. The four members are defined formally here, and their type sections are in Robin Hood's Bay.

**Ironstone Shale Member** (beds 527–590; 62.73 m thick). Mudstones and shales, grey, soft, with some beds of micaceous silty shales, many grey sideritic mudstone nodules, weathering red on the outside, and a few calcareous mudstone nodules. The nodules are scattered sparsely through the shale, but are more often developed at single horizons, either scattered or as near-continuous beds. The distinctive beds of red-weathering nodules have frequently been referred to as 'ironstones', but they are better described as sideritic mudstones.

The base is defined at the bottom of bed 527 in Robin Hood's Bay, which is a prominent continuous bed of sideritic mudstone weathering red-brown. Although sideritic mudstone nodules occur at several

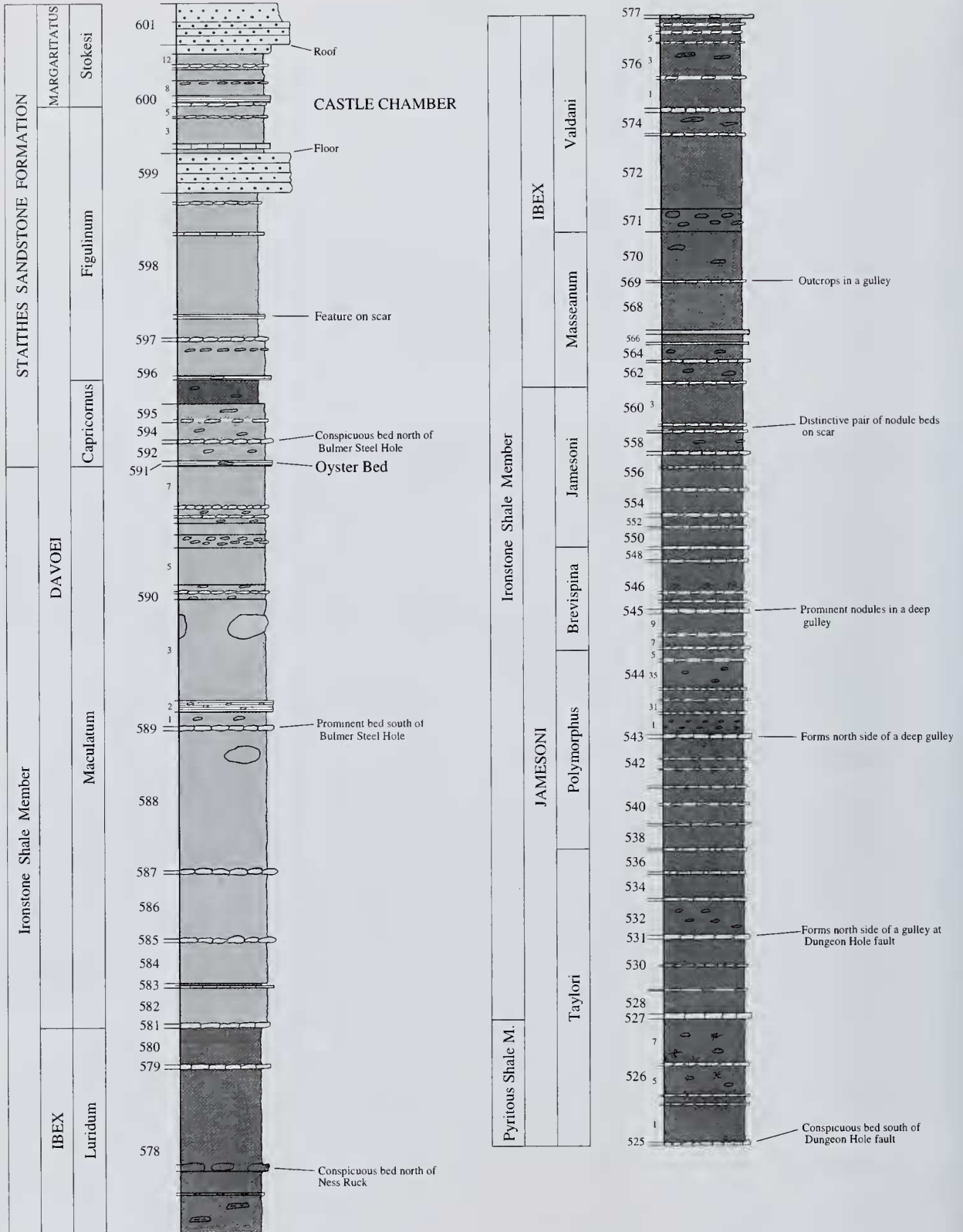
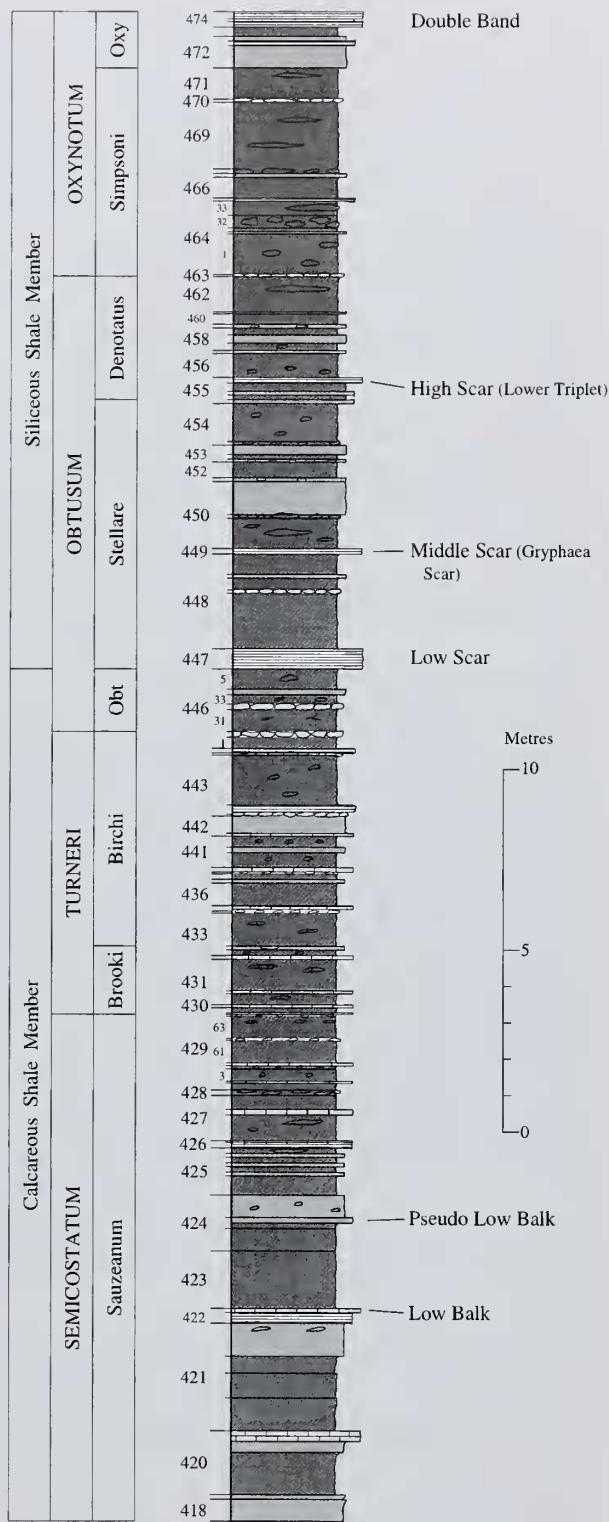
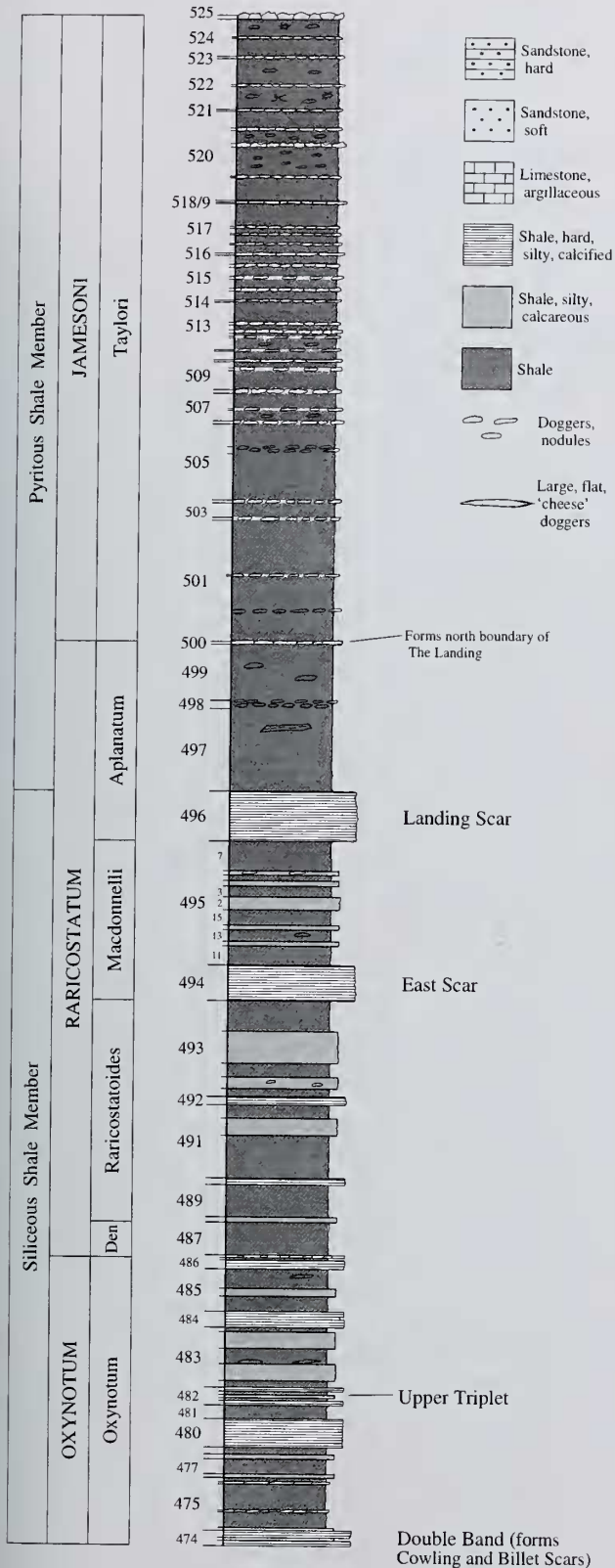


Fig. 18 Vertical section of the Lower Lias of Robin Hood's Bay, showing the main lithological features, relative thickness of all the beds, and named beds and other beds that form prominent features on the foreshore.





lower horizons down as far as bed 500 and those of bed 525 are especially conspicuous, pyrites is very common at most horizons up to bed 526.7 but does not occur higher. So the strong sideritic mudstone of bed 527 is a good base for this member. Such sideritic mudstone nodules and occasional continuous beds are a feature of the whole thickness of the member up to the base of the Staithes Sandstone Formation. Several of them form prominent features on the scars, eg. beds 527, 531, 543, 545, 559 and 560.2 (a distinctive pair of nodule beds), 569, 578.4 and 589.

**Pyritous Shale Member** (beds 497–526; 26.18 m thick). Consists of dark grey, soft and micaceous shales, with many calcareous and/or sideritic mudstone nodules; there are many nodules or irregular masses of iron pyrites, especially in the lower part. This member is similar to the Ironstone Shale Member in containing both calcareous and sideritic mudstone nodules, but it also contains much iron pyrites as irregular nodules or masses of crystals.

The base is defined here as the bottom of bed 497 in Robin Hood's Bay. This is the horizon at which the sand and silt content almost disappears and calcification is much diminished, leaving the beds above as softer shales. Iron pyrites is common at many horizons, appearing variously as irregular masses or strings of pyrites, or pyrite-rich concretions, and many of the fossils are partly pyritized in these beds. The softness of the shale leads to this part of the succession forming the wettest and lowest part of the bay relative to sea level.

**Siliceous Shale Member** (beds 447–496; 38.74 m thick). Dark-grey shales, interbedded with much harder and lighter-coloured beds of calcified mudstones, silts and fine sandstones; a few nodules and doggers of calcareous or sideritic mudstone occur. This member forms the series of hard calcified beds alternating with soft shales that is typical of the lower part of the succession in Robin Hood's Bay. Red-weathering sideritic nodules are now scarce, and most of the harder beds are calcareous cemented muds and silts, in which the arenaceous content is higher than in the underlying Calcareous Shale Member. Large, circular 'cheese' doggers of hard argillaceous limestone, containing vertically orientated crystals of calcite, occur at several horizons in both this member and the Calcareous Shale Member below. Such doggers are generally up to only about 10 cm thick, but they can reach 2.5 m in diameter; they occur at 7 levels between beds 450 and 471.

The base is defined here at the bottom of bed 447 (Low Scar) in Robin Hood's Bay. This is the first prominent bed of very hard calcified shale or argillaceous limestone that has a significant sand content. Sand and silt occur in many of the hard calcified shales or sandstones at horizons up to the base of the Pyritous Shale Member. Most of the prominent 'scars' in the bay are formed of beds in this member – ie. Low Scar, Middle Scar (Gryphaea Scar), High Scar (Lower Triplet), Double Band (Cowling Scar and Billet Scar), Upper Triplet, East Scar and Landing Scar.

**Calcareous Shale Member** (beds 418–446; 23.35 m thick). Dark-grey shales, interbedded with hard, calcified, silty mudstones; doggers of calcareous mudstone and some beds of limestone also occur; cone-in-cone enveloped calcareous mudstone nodules also occur at several horizons. This member is less arenaceous than the Siliceous Shale Member, the hard beds now having no sand and less silt, and the hardness being due mainly to calcification. The very prominent Low Balk and the less prominent Pseudo Low Balk are formed by limestones or highly calcified shales. Large 'cheese' doggers, similar to those in the Siliceous Shale Member, are found at three levels in beds 425–429.

In Robin Hood's Bay the base has to be placed at the lowest

horizon exposed, ie. at the base of bed 418. If it is thought that the base should coincide with the base of the Redcar Mudstone Formation, then it must be defined at the same level (ie. 288.87 m depth) in the BGS Felixkirk Borehole (Cox *et al.* 1998: 35).

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## EXPOSURES IN ROBIN HOOD'S BAY NOW

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The extent of the foreshore exposures of the solid geology on the north Yorkshire coast has always depended on the vagaries of shifting sand and boulder cover, algal growth, barnacle growth, and major cliff falls, all caused or cleared away by the actions of tides and storms. But in the last 25 years much more extensive, and possibly more permanent, sand, boulder, algal and barnacle cover, and mussel beds have made major inroads into the amount of rock exposed in some areas. Especially serious on some of the scars are mussel beds that trap mud and silt to form a thick, impenetrable cover that completely obscures the rock underneath. At the end of the 1990s the foreshore exposures were largely obscured from Way Foot at the bottom of Robin Hood's Bay Town northwards to just south of Dungeon Hole. In fact there are few or no exposures of beds 497–525 owing to the sand and seaweed cover, which has possibly been exacerbated by the high concrete seawall built to protect Robin Hood's Bay in 1975. That seawall covers the cliff face of the same beds, so that they are not now exposed in either the cliff face or on the foreshore. Exposures improve upwards from bed 526, especially north of the Dungeon Hole fault, though there is still much algal growth and large areas are covered by loose boulders. Around the north side of the bay in the top half of Map 1 (Fig. 5) the foreshore continues to be washed clean by tides and storms and exposures are still good. Exposures seaward and south of Boggle Hole (Map 3; Fig. 8) are also better, and they are good in front of Peter White Cliff (Map 4; Fig. 11). The lowest beds on the latter map, especially from bed 430 down to below Low Balk have always suffered from algal cover, of which *Laminaria* is a significant factor at those low sea-levels, but barnacle growth is also very pronounced and makes observations difficult on some beds.

For most of the past two centuries the foreshore of Robin Hood's Bay has been largely clear of such cover, and collectors from Young & Bird in the 1820s, Phillips, Tate & Blake, the Geological Survey in 1880–1910, up to Bairstow in the period from 1928 to the 1950s (see Fig. 7) were able to make significant fossil collections from all the beds. In particular, most of them obtained large specimens of *Apoderoceras* from the Taylori Subzone of beds 501 to 526. No such specimens can be collected today. The foreshore was largely clean in 1969 when Bairstow conducted a field party from the William Smith Jurassic Symposium to the Bay, but deterioration proceeded rapidly from the early 1970s. Bairstow's work could not be repeated today, at least for the beds on Map 2 (Fig. 6) from Robin Hood's Bay town northwards to the top of that map.

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## CORRELATION WITH PREVIOUS DESCRIPTIONS

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The Lower Lias of Robin Hood's Bay was mentioned by Young & Bird (1822, 1828) and Phillips (1829, 1875), and a few ammonites from the bay were figured by them, but their descriptions were not in sufficient detail to be correlated with the work in this paper. Prior to Bairstow's work, detailed descriptions were published by Simpson (1868, 1884), Tate & Blake (1876) and Buckman (1915), all of whom numbered their beds from the top downwards. After Bairstow prepared his maps and stratigraphical descriptions, detailed accounts

of the geology of parts of the bay were published by Howarth (1955), Phelps (1985) and Hesselbo & Jenkyns (1995). The tables of Figs 19 and 20 give bed-by-bed correlation columns for all these schemes in as much detail as is possible; the columns of subzones in both figures are the subzones as determined in this paper.

Simpson first described the beds in 1868 (Simpson, 1868: 53–56), but in his later work (Simpson, 1884: xvii–xxii) there are more details at some horizons, and the Simpson columns in the tables are based on his later work. Tate & Blake (1876: 63–65, 73–75, 79–81, 91, 92, 109, 110) described the beds in greater detail, and in many parts of the succession their beds correspond closely with those in the present paper, though they omitted about 3 m of strata within their group Jam.30–Jam.32. Tate & Blake (1876: 79, 91–2) also duplicated part of the succession in their descriptions, inasmuch as their Jamesoni beds 1–7 are the same as their Capricornus beds 28–33 (these are shown in Fig. 19 as Jam.1–Jam.7 only).

The Geological Survey's description of the succession first appeared in the memoir of Fox-Strangways & Barrow (1882: 4–10), where the beds were described in detail but not numbered, and the ammonites that they listed for individual beds are not accurately determinable in modern terms. The same description was used by Buckman (1915: 67–74) in his appendix to the 2<sup>nd</sup> edition of that memoir: the same basic data was used for the succession, but the beds were sometimes combined into thicker units and were now given numbers; lithological names were given to a few of the beds, and Buckman's determinations of the ammonites and zonal divisions were added. Buckman's 1915 description of the sequence is used for Figs 19 and 20, rather than the original 1882 description.

Howarth (1955: 155) described beds upwards from the bottom of the Upper Pliensbachian; the equivalence of his beds 1–6 are shown at the top of Fig. 19, with bed 1 being the same as beds 600.5 and 600.6, while the equivalence of a few lower beds that were given roman numbering in the upper part of the Figulinum Subzone is indicated in the detailed stratigraphical section above (p. 98).

Phelps (1985: fig. 4) described the succession in the Davoei and upper part of the Ibex Zones in detail. When the vertical tabular section of his fig. 4 is compared at the same scale with the tabular section of Fig. 18 here, good correlations can be made from his top bed near the top of the Figulinum Subzone down to his bed 4b (= bed 567) in the Masseanum Subzone, and at the bottom it seems fairly certain that his bed 1 is the same as bed 561. Phelps (1985: pl. 1, figs 1, 3, pl. 2, figs 1, 6, 8) figured five ammonites from his beds 21, 23, 37, 47 and 63, the identifications of which are discussed below (pp. 141–144) in the description of the ammonite genus *Aegoceras*.

Hesselbo & Jenkyns's (1995) sequence of the Lower Lias of Robin Hood's Bay was based on new observations made by them. Their bed numbers are original from the bottom of the sequence up to their bed 121 at the base of the Masseanum Subzone, then higher up they used the bed numbers of Phelps (1985), and finally the bed numbers of Howarth (1955) upwards from the top of the Figulinum Subzone. Although their descriptions and measurements were new, above bed 121 their identification and use of Phelps' bed numbers is difficult to interpret at some horizons, especially in the Ibex Zone, so in Fig. 19 the correlation of Phelps' beds 1–65 is based on Phelps' original description of that sequence, not on Hesselbo & Jenkyns' re-interpretation of it. However, from the base of the sequence up to bed 121, Hesselbo & Jenkyns' description can be readily correlated with that of this paper at most levels, and is shown as their beds 1–121 in the relevant columns of Figs 19 and 20. The main areas of uncertainty are at the bottom of the succession below their bed 23 (=bed 447), though it appears likely that their bed 5 has been correctly identified as bed 422 (Low Balk), in their beds 73–94 in the Taylori Subzone, that are difficult to correlate in detail, and in beds 113–121

in the Brevispina and Jamesoni Subzones. In the upper part of the sequence between beds 102 and 116, a strikingly similar pattern can be seen by comparing Hesselbo & Jenkyns' tabular section side-by-side with that of Fig. 17; eg. bed 102 = bed 527; 104 = 531; 112 = 543; 114, lower part = 545, and it is probable that bed 116 is the same as bed 547. Bed 1 of Phelps has already been correlated with bed 561, so this leaves Hesselbo & Jenkyns' beds 117–121 (4.5 m thick) as equivalent to Bairstow beds 548–560 (6.3 m thick), but there are some differences in thickness and they are not correlatable in detail. The position of the subzone boundaries given by both Phelps and Hesselbo & Jenkyns differ in detail from those determined for this paper, except for the upper parts of the Raricostatum and Davoei Zones.

In addition to the previous descriptions in the works listed above, Getty measured and collected ammonites from the Oxynotum and Raricostatum Zones in the bay. The stratigraphical part of his work is only available in his unpublished thesis (Getty, 1972), but many of the ammonites he collected were described in his revision of the family Echioceratidae (Getty, 1973), and they are in the collections of the Natural History Museum. His stratigraphical sequence of ammonites and biostratigraphical divisions are very similar to those of Bairstow as determined here.

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## BAIRSTOW'S AMMONITE COLLECTION

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More than 2360 ammonites were collected by Bairstow. The majority were obtained in the years 1927–1935, but small numbers of specimens were added up to about 1970. In addition there are a few specimens that were given to him by other collectors: the majority came from Dr J. Coggin Brown, who collected well-preserved ammonites at Robin Hood's Bay in the period 1940–1960 (on retiring to north-east England after working for the Geological Survey of India). Bairstow checked the horizons of the specimens given to him with great care, and only those that he was satisfied came from definitely identifiable beds are included amongst those listed in this paper. All Bairstow's ammonites are preserved in collections of the Department of Palaeontology, The Natural History Museum, London, and most have been given Museum registration numbers, in addition to the collecting numbers given by Bairstow. The identifiable Liparoceratidae were registered for Spath's (1938) catalogue of that family, and received some of the numbers in the series C.38871–C.39579; some of the Eoderoceratidae were registered in the late 1950s in the series C.49314–C.49431; the remainder of the collection was registered in 2000 with the numbers CA 2744–CA 4608. The three nautiloids in his collection have the numbers CN 86, 87 and 93.

In 1928 Bairstow consulted with S.S. Buckman, a year or two before his death, who had expressed interest in the ammonites he was collecting in the bay. From his earlier work on ammonites collected by the Geological Survey, Buckman knew that the succession up to the top of the Sinemurian was exposed in both the north-western and south-eastern parts of the bay. The sequences of ammonites that Bairstow was obtaining in the two outcrops that are up to 3 km apart seemed to Buckman to be a good opportunity to test his hemeral theory<sup>1</sup>, and he advised Bairstow to record the geographical position,

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<sup>1</sup>Briefly, Buckman's theory of hemera was that every species of ammonite reached its acme of abundance at a unique time that did not overlap with the acme of any other species. By discovering the order in which ammonites reached their acme, a sequence of 'hemerae' could be constructed, which would be smaller and finer divisions than ammonite subzones and would be applicable over wide areas. Contemporary palaeontologists were sceptical of the theory, and work by many palaeontologists during the following 70 years has shown that the hemeral theory is not valid.



SIMPSON 1868, 1884	TATE & BLAKE 1876	BUCKMAN 1915	HESELBO & JENKYNs 1995	THIS PAPER	SUBZONES
LL 2 <sub>1</sub>	Jam. 56	Ch. 16	72	500	Aplanatum
LL 2 <sub>2</sub>	Jam. 57	Ch. 17	71	499	
	Jam. 58	Ch. 18			
	Jam. 59	Ch. 19	70	498	
LL 1 <sub>1</sub>	Jam. 60	Ch. 20	69	497	
	Ox. 1	Ch. 21	68	496	Macdonnelli
LL 1 <sub>2-13</sub>	Ox. 2		67	495.7	
	Ox. 3		66	495.3-.6	
			65	495.15-.2	
	Ox. 4		64	495.11-.14	
LL 1 <sub>2-13</sub>	Ox. 5		63	494	
			62	493.5	
	Ox. 6-12		61	493.4	
			60	493.1-.3	
			59	492	
	LL 1 <sub>2-13</sub>		Ox. 6-12	58	491
				57	490
				56	489
				55	488
				54	487
LL 1 <sub>2-13</sub>		Ox. 6-12		53	486.3
				52	486.1-.2
				51	485
				50	484
				49	483.4-.5
	48		483.1-.3		
	47		482		
	46		480-81		
	45		479		
	44		478		
LL 1 <sub>2-13</sub>	Ox. 6-12	43	477		
		42	476		
		41	475.4-.6		
		40	475.3		
		39	475.1-.2		
		38	474.3-473		
		37	474.2		
		36	474.1		
		35	472.2		
		34	472.1		
LL 1 <sub>2-13</sub>	Ox. 6-12	33	471		
		32	470		
		31	469		
		30	468		
		29	467		
		28	466.3-.5		
		27	466.2		
		26	466.1		
		25	465		
		24	464.3		
LL 1 <sub>2-13</sub>	Ox. 6-12	23	464.2		
		22	464.1		
		21	464		
		20	463		
		19	462		
		18	461		
		17	460		
		16	459		
		15	458		
		14	457		
LL 1 <sub>2-13</sub>	Ox. 6-12	13	456		
		12	455.5		
		11	455.2-.4		
		10	455.1		
		9	454		
		8	453.3		
		7	453.1-.2		
		6	452		
		5	450.3-451		
		4	450.1-.2		
LL 1 <sub>2-13</sub>	Ox. 6-12	3	449		
		2	448.5		
		1	448.1-.4		
		447	447		
		446.5	446.5		
		446.4	446.4		
		446.3	446.3		
		446.2	446.2		
		446.1	446.1		
		445	445		
LL 1 <sub>2-13</sub>	Ox. 6-12	444	444		
		443.3	443.3		
		443.1-.2	443.1-.2		
		442.2	442.2		
		442.1	442.1		
		441	441		
		440	440		
		438-39	438-39		
		437	437		
		436	436		
LL 1 <sub>2-13</sub>	Ox. 6-12	435	435		
		433.3-434	433.3-434		
		433.1-.2	433.1-.2		
		432	432		
		431.3	431.3		
		431.2	431.2		
		429.7-431.1	429.7-431.1		
		429.6	429.6		
		429.5	429.5		
		429.1-.4	429.1-.4		
LL 1 <sub>2-13</sub>	Ox. 6-12	426-28	426-28		
		425	425		
		424.3	424.3		
		424.1-.2	424.1-.2		
		423	423		
		422.2	422.2		
		422.1	422.1		
		421	421		
		420	420		
		418-19	418-19		

SIMPSON 1868, 1884	TATE & BLAKE 1876	BUCKMAN 1915	HESELBO & JENKYNs 1995	THIS PAPER	SUBZONES
LL 20 <sub>2</sub>	Ox. 31	Sin. 5-8	35	462	Denotatus
LL 21 <sub>1</sub>			461		
LL 21 <sub>2</sub>			34	458-60	
			33	457	
			32	456	
LL 21 <sub>2</sub>	Ox. 32	Sin. 9	31	455.5	
			30	455.2-.4	
	Ox. 33	31	455.1		
	Ox. 34	30	454		
	Ox. 35	29	453		
LL 21 <sub>2</sub>	Ox. 36	Sin. 10	28	453.1-.2	
			27	452	
	Ox. 37	26	450.3-451		
	Ox.38, 39	25	450.1-.2		
	24	449			
LL 22 <sub>1</sub>	Ox.40	23	448.5		
LL 22 <sub>2</sub>	Ox.41	22	448.1-.4		
LL 23 <sub>1-26</sub>	Ox. 42	Sin. 11	21	447	
			20	446.5	
	Buckl. 1		19	446.4	
			18	446.3	
	Buckl. 2		17	446.2	
			16	446.1	
	Buckl. 3		15	445	
			14	444	
	Buckl. 4		13	443.3	
			12	443.1-.2	
Buckl. 5	11	442.2			
	10	442.1			
Buckl. 6	9	441			
	8	440			
Buckl. 7	7	438-39			
	6	437			
LL 23 <sub>2-26</sub>	Buckl. 8	Sin. 12	5	436	
			4	435	
	Buckl. 9		3	433.3-434	
			2	433.1-.2	
	Buckl. 10-21		1	432	
0		431.3			
LL 27 <sub>1-2</sub>	Ox. 31	Sin. 13	13	431.2	
			12	429.7-431.1	
			11	429.6	
			10	429.5	
			9	429.1-.4	
LL 27 <sub>1-2</sub>	Ox. 31	Sin. 13	8	426-28	
			7	425	
			6	424.3	
			5	424.1-.2	
			4	423	
LL 27 <sub>1-2</sub>	Ox. 31	Sin. 13	3	422.2	
			2	422.1	
			1	421	
			0	420	
			418-19	418-19	

Fig. 20 Correlation of the bed numbers used in this paper for the Sinemurian with divisions used in previous descriptions of the Lower Lias of Robin Hood's Bay; the subzones in the right hand columns are those determined in this paper. See text for details of the sources of the previous descriptions.

as well as the stratigraphical horizon, of all his specimens. Bairstow did this by drawing 17 datum lines on his copies of the maps (ie. they are not on the originals in King's College, Cambridge). Each was a straight line crossing the foreshore from the base of the cliff to the seaward edge of the scar; most cross the foreshore approximately at

right angles to the cliff, but a few cross at an oblique angle. Originally he chiselled marks on the outcrops to record the exact position of each datum line, but all such marks have long since disappeared. Each ammonite he collected was related to the nearest point on a datum line by pacing yards (0.9 m) from the intersection of the line

with the bottom of the cliff, then yards at right angles to the line up to the position of the ammonite. By these means the geographical position of each ammonite was recorded to approximately the nearest square yard. This information, which is not included in this paper, occurs on many of the original specimen labels that are with the ammonites in his collection.

In 1957 Bairstow prepared a bed-by-bed list of the identifications of every ammonite in his collection. This is a large manuscript amounting to 390 pages. Not only is it a list of the specimens then in the collection (over the years a small number had decayed or were lost), but its main value is as a record of the identifications made by Dr L.F. Spath. He saw the specimens as Bairstow collected them, and made identifications that date mainly from the period 1927–40, while a few were checked or reidentified by him up to 1956. In preparing the list of ammonites for this paper, all the identifications were verified, mainly in order to produce a consistent set of determinations from which the account of the biostratigraphy could be prepared, but also to revise the generic attributions of the species according to modern usage of the various genera. In general Spath's identifications were found to be accurate, and only a few needed revision. The only previous publication of any of Spath's identifications was in his catalogue of the Liparoceratidae (Spath, 1938), where all the Robin Hood's Bay Liparoceratidae collected up to 1937 were listed by register number.

## SYSTEMATIC DESCRIPTION OF THE AMMONITES AND NAUTILOIDS

This section is not intended to be a full description of the ammonites in the Sinemurian and Lower Pliensbachian of Robin Hood's Bay, but all ammonites that have been figured before are included in a list in systematic order, and this gives an indication of their synonymies. All the Robin Hood's Bay ammonites that have been described or figured by the following authors are included: J. Sowerby and J. de C. Sowerby (1812–1846), Young & Bird (1822, 1828), Phillips (1829, 1835, 1875), Brown (1837, 1889), Simpson (1843, 1855, 1884), Blake (1876), Wright (1878–82), Hyatt (1889), Buckman (1909–30), Spath (1923*b*, 1924, 1925*a*, 1938, 1956), Trueman & Williams (1925), Jaworski (1931), Howarth (1955, 1962), Dean *et al* (1961), Howarth & Donovan (1964), Guérin-Franiatte (1966), Getty (1973), Donovan & Forsey (1973), Schlegelmilch (1976, 1992), Phelps (1985), Dommergues (1987) and Dommergues & Meister (1992).

All the ammonites listed are from Robin Hood's Bay, except where indicated otherwise, and the beds from which the type and figured specimens might have come are identified with varying degrees of confidence, as indicated in the list; register numbers are given, where known. The list also shows the data on which the identifications in the paper are based (eg. by giving references to the type specimens in most cases, including those that are not Yorkshire specimens). 56 of the better preserved ammonites in Bairstow's collection are figured to illustrate the identifications and the contents of some of the subzones. Further discussion of synonymies, identifications and distribution in the zones and subzones is found in the section on Biostratigraphy, and more details of the identifications of the type specimens of some species can be found in Howarth (1962). All measurements are in millimetres (mm); D = diameter, Wh = whorl height, Wb = whorl breadth, U = diameter of the umbilicus.

Order **AMMONOIDEA** Zittel, 1884  
Suborder **PHYLLOCERATINA** Arkell, 1950  
Family **JURAPHYLLITIDAE** Arkell, 1950  
Genus **TRAGOPHYLLOCERAS** Hyatt, 1900

### *Tragophylloceras numismale* (Quenstedt, 1845)

Pl. 1, fig. 1

- 1843 *Ammonites huntoni* Simpson: 41.  
1845 *Ammonites heterophyllus numismalis* Quenstedt: 100, pl. 6, figs 4a, b, 5a, b, *non* figs 3a, b, 5c (figs 5a, 5b, from Germany, designated lectotype by Buckman, 1912: *viii*).  
1855 *Ammonites nanus* Simpson: 38.  
1921 *Tragophylloceras huntoni* (Simpson); Buckman: pl. 219 (paratype or holotype, WM 477; ?from bed 517 or 520).  
1926 *Tragophylloceras nanum* (Simpson); Buckman: pl. 679 (holotype, WM 472; from bed 517 or 520).  
1964 *Tragophylloceras numismale* (Quenstedt); Howarth & Donovan: 295, pl. 48, fig. 5 (BM C.67766; from bed 517 or 520).

RANGE. Beds 505.2–544.5, Taylori to Polymorphus Subzones; 17 specimens.

### *Tragophylloceras loscombi* (J. Sowerby, 1817)

- 1817 *Ammonites loscombi* J. Sowerby: 185, pl. 183.  
1843 *Ammonites ambiguum* Simpson: 8.  
1843 *Ammonites robinsoni* Simpson: 42.  
1910 *Rhacoceras ambiguum* (Simpson); Buckman: pl. 16 (holotype, WM 89; ?from bed 569).  
1914 *Tragophylloceras loscombi* (J. Sowerby); Spath: 336, pl. 49, fig. 1 (holotype, from Dorset).  
1921 *Tragophylloceras robinsoni* Buckman: pl. 220 (paratype, WM 478; ?from bed 569).  
1964 *Tragophylloceras loscombi* (J. Sowerby); Howarth & Donovan: 301, pl. 49, figs 4–7 (from Dorset).

RANGE. Found in bed 569 only, Masseanum Subzone; 2 specimens.

REMARKS. This single specimen high in the Masseanum Subzone is at a lower horizon than specimens in Dorset, where they have not been recorded from below the Luridum Subzone (Howarth & Donovan, 1964: 293, 302).

Suborder **LYTOCERATINA** Hyatt, 1889  
Superfamily **LYTOCERATACEAE** Neumayr, 1875  
Family **LYTOCERATIDAE** Neumayr, 1875  
Genus **LYTOCERAS** Suess, 1865

### *Lytoceras fimbriatum* (J. Sowerby, 1817)

Pl. 1, fig. 3

- 1817 *Ammonites fimbriatus* J. Sowerby: 145, pl. 164.  
1919 *Fimbriilytoceras fimbriatum* (J. Sowerby); Buckman: pl. 130A–C (from Dorset).

RANGE. Beds 570–578.5, Ibx Zone; 25 specimens. Two *Lytoceras* of indeterminate species were found in beds 568 (top) and 584.

REMARKS. *Lytoceras fimbriatum* is confined to the Ibx Zone in Robin Hood's Bay, except for one poorly preserved specimen in bed 584 (Maculatum Subzone) that can only be determined as *Lytoceras* sp. indet. Many of those in the Ibx Zone are large and well-preserved, and one of the best specimens is figured in Pl. 1, fig. 3. Sowerby's figured specimen, now lost, was from Dorset.

Suborder **AMMONITINA** Zittel, 1884  
 Superfamily **PSILO CERATA CEAE** Hyatt, 1867  
 Family **PSILO CERATIDAE** Hyatt, 1867

Blocks of limestone containing *Psiloceras*, *Caloceras* and other Hettangian and Lower Sinemurian ammonites are sometimes found loose in Robin Hood's Bay, and species have been described by several authors as coming from 'Robin Hood's Bay'. They are not from the inter-tidal exposures (the lowest of which is in the upper part of the Semicostatum Zone), but are derived from Glacial Drift nodules that are widespread in the bay and were exploited by 19th century collectors.

Genus **PSILO CERAS** Hyatt, 1867

***Psiloceras erugatum*** (Phillips, 1829)

- 1829 *Ammonites erugatus* Phillips: 163, pl. 13, fig. 13; also Phillips, 1835: 135, pl. 13, fig. 13; and Phillips, 1875: 270, pl. 13, fig. 13.  
 1962 *Psiloceras erugatum* (Phillips); Howarth: 99, pl. 14, fig. 2 (holotype, BM 37982, from 'Robin Hood's Bay').

***Psiloceras aff. sampsoni*** (Portlock, 1843)

- 1879/81 *Aegoceras planorbis* (J. Sowerby); Wright: 308 (1881), pl. 14, figs 1, 2 (1879) (SM J18216, from 'Robin Hood's Bay').

Genus **CALOCERAS** Hyatt, 1870

***Caloceras belcheri*** (Simpson, 1843)

- 1843 *Ammonites belcheri* Simpson: 12.  
 1910 *Caloceras belcheri* (Simpson); Buckman: pl. 17 (holotype, WM 101, from Robin Hood's Bay).  
 1879/81 *Aegoceras belcheri* (Simpson); Wright: 313 (1881), pl. 15, figs 7, 8 (1879) (SM J18217, from Robin Hood's Bay), 9.  
 1976 *Psiloceras (Caloceras) johnstoni* (J. de C. Sowerby); Schlegelmilch, 1976: 106, pl. 5, fig. 8 (WM 101).

***Caloceras convolutum*** (Simpson, 1855)

- 1855 *Ammonites convolutus* Simpson: 43 (*non Ammonites convolutus* Schlotheim, 1820).  
 1910 *Caloceras convolutum* (Simpson); Buckman: pl. 18 (holotype, WM 491, from Robin Hood's Bay).

***Caloceras wrighti*** Spath, 1924

- 1880/81 *Aegoceras belcheri* (Simpson); Wright: 313 (1881), pl. 19, figs 1, 2 (1880) (holotype, from North Cheek, Robin Hood's Bay, ?lost).  
 1924 *Caloceras wrighti* Spath: 191 (*nom. nov.* for Wright's figured specimen).

Family **SCHLOTHEIMIDAE** Spath, 1923

Genus **SCHLOTHEIMIA** Bayle, 1878

***Schlotheimia redcarensis*** (Young & Bird, 1822)

- 1822 *Ammonites redcarensis* Young & Bird: 248, pl. 14, fig. 13; also Young & Bird, 1828: 258, pl. 14, fig. 10.  
 1925 *Schlotheimia redcarensis* (Young & Bird); Buckman, pl. 608 (neotype, WM 314; if from Robin Hood's Bay, as labelled, it must be from Glacial Drift).

Genus **SAXOCERAS** Lange, 1924

***Saxoceras aequale*** (Simpson, 1855)

- 1855 *Ammonites aequalis* (Simpson): 49.  
 1925a *Saxoceras aequale* (Simpson); Spath: 204, fig. 4 (drawing of holotype, BM 18109).  
 1962 *Saxoceras aequalis* Howarth: 100, pl. 14, fig. 3 (holotype, BM 18109, from Robin Hood's Bay or Redcar, more probably the latter).

Genus **ANGULATICERAS** Quenstedt, 1883

***Angulaticeras sulcatum*** (Simpson, 1843)

- 1843 *Ammonites sulcatus* Simpson: 55 (*non Ammonites sulcata* Lamarck, 1822).  
 1911 *Schlotheimia sulcata* (Simpson); Buckman: pl. 38 (holotype, WM 743; ?from beds 461–464).  
 1976 *Angulaticeras sulcatum* (Simpson); Schlegelmilch: 112, pl. 8, fig. 7 (WM 743).

RANGE. Six small examples of *Angulaticeras* sp. indet. were found in beds 461–464.33 and 485.2, Denotatus to Oxynotum Subzones.

Genus **MACROGRAMMITES** Buckman, 1928

***Macrogrammites antiquatum*** (Simpson, 1855)

- 1855 *Ammonites antiquatus* Simpson: 36.  
 1927 *Schlotheimia antiquata* (Simpson); Buckman, 1927, pls 718A, B (holotype, WM 79/80); if this holotype is a large smooth outer whorl of the Hettangian genus *Macrogrammites* as identified by Buckman (1928: on caption to pl. 718A\* [re-issue of 1927, pl. 718A]), then it comes from Glacial Drift in Robin Hood's Bay, or from Redcar; it is not from beds exposed in Robin Hood's Bay.

Family **ARIETITIDAE** Hyatt, 1875

Subfamily **ARIETITINAE** Hyatt, 1875

Genus **CORONICERAS** Hyatt, 1867

Subgenus **ARIETITES** Waagen, 1869

***Coroniceras (Arietites) alcinoe*** (Reynès, 1879)

Pl. 1, fig. 8

- 1879 *Ammonites alcinoe* Reynès: pl. 23, figs 7, 8, 9–11 (neotype, from France).  
 1955 *Paramioceras alcinoe* (Reynès); Donovan: 14.

RANGE. Beds 424.3–429.64, Sauzeanum Subzone; 5 specimens.

***Coroniceras (Arietites) validanfractum*** (Simpson, 1855)

- 1855 *Ammonites validanfractus* Simpson: 95.  
 1962 *Coroniceras validanfractum* Howarth: 101, pl. 14, figs 4 (holotype, WM 282), 5 (paratype, WM 530); similarly preserved specimens have been found at Redcar, but not at Robin Hood's Bay; this species is close to *C. (A.) alcinoe* (Reynès).

***Coroniceras (Arietites) obesulus*** (Blake, 1876)

- 1876 *Arietites obesulus* Blake: 284, pl. 5, fig. 2 (lectotype, SM J34800, from Robin Hood's Bay); also very similar to *C. (A.) alcinoe* (Reynès).





*?Coroniceras (Arietites) radiatus* (Simpson, 1843)

- 1843 *Ammonites radiatus* Simpson: 47 (*non Ammonites radiatus* Bruguière, 1789).  
 1911 *Arietites radiatus* (Simpson); Buckman: pl. 35 (holotype, WM 304, possibly from beds 426–429, but it is only 12 mm diameter and is not identifiable).

*Coroniceras (Arietites) cf. planaries* (Reynès, 1879)

- 1878/81 *Arietites nodulosus* (Young & Bird); Wright: 288 (1881), pl. 6, figs 2, 3 (1878) (C.1880, possibly from beds 426–429).

Genus *ARNIOCERAS* Hyatt, 1867

*Arnioceras semicostatum* (Young & Bird, 1828)

Pl. 1, fig. 2

- 1828 *Ammonites semicostatus* Young & Bird: 257, pl. 12, fig. 10.  
 1855 *Ammonites vetustus* Simpson: 88.  
 1876 *Arietites semicostatus* (Young & Bird); Blake: 288, pl. 5, fig. 4a (upper figure, BM C.17935; lower figure, BM C.17934 (?malformation); both from Redcar).  
 1876 *Arietites difformis* (Emmrich); Blake: 289, pl. 6, fig. 3 (C.17933, possibly from Redcar).  
 1889 *Arnioceras semicostatum* (Young & Bird); Hyatt: 165, pl. 2, figs 12, 13 (from 'Whitby', presumably from Robin Hood's Bay).  
 1918 *Arnioceras semicostatum* Buckman: pl. 112 (holotype, WM 924).  
 1925a *Arnioceras semicostatum* (Young & Bird); Spath: 329, fig. 10a (BM C.86a).  
 1931 *Arnioceras semicostatum* (Young & Bird); Jaworski: 111, pl. 5, fig. 1 (WM 924).  
 1956 *Arnioceras semicostatum* (Young & Bird); Spath: 153, pl. 10, figs 6 (BM C.25651), 7 (BM C.17933).  
 1961 *Arnioceras semicostatum* (Young & Bird); Dean *et al.*: pl. 65, fig. 4 (BM C.25651).  
 1962 *Arnioceras vetustum* (Simpson); Howarth: 103, pl. 15, fig. 2 (holotype, GSM 26404, ?from bed 421 or 424).  
 1976 *Arnioceras semicostatum* (Young & Bird); Schlegelmilch: 138, pl. 21, fig. 4 (WM 924).

RANGE. Beds 421.4–429.64, Sauzeanum Subzone; 118 specimens.

REMARKS. Jaworski's (1931: pl. 5, fig. 1) enlarged figure of the holotype is much better than Buckman's (1918) figure. Older collections contain many well-preserved *Arnioceras semicostatum* from limestone nodules. Such good specimens were not found by Bairstow and they have sometimes been considered to come from Glacial

Drift, but judging from the preservation it is possible that they came from nodules near the top of bed 421.4 or from beds 424.2 or 424.3. Although *Arnioceras* persists elsewhere into the overlying Brooki and Birchi Subzones, all the well-preserved Robin Hood's Bay specimens appear to have come from these limestone nodules of the Sauzeanum Subzone. One of the better examples in Bairstow's collection is figured in Pl. 1, fig. 2.

The range of *Arnioceras* is extended down to bed 421.1 and up to beds 430–436 by six specimens of indeterminate species found by Bairstow.

*Arnioceras acuticarinatum* (Simpson, 1855)

- 1855 *Ammonites acuticarinatum* (Simpson): 94  
 1911 *Arnioceras acuticarinatum* (Simpson); Buckman: pl. 40 (holotype, WM 295; ?from beds 421–424).  
 1931 *Arnioceras acuticarinatum* (Simpson); Jaworski: 126, pl. 5, fig. 2 (WM 295).  
 1976 *Arnioceras acuticarinatum* (Simpson); Schlegelmilch, 1976: 138, pl. 21, fig. 3 (WM 295).

REMARKS. The best figure of the holotype is that of Jaworski, and such a well-preserved specimen might have come from beds 421–424. Its more finely ribbed inner whorls possibly separate it from *A. semicostatum*.

*Arnioceras miserabile* (Quenstedt, 1856)

- 1856 *Ammonites miserabilis* Quenstedt: 71, pl. 8, fig. 7.  
 1876 *Aegoceras nigrum* Blake: 274, pl. 6, fig. 6 (lectotype, BM C.17889, possibly from bed 424.2 or 424.3).  
 1884 *Ammonites miserabilis* Quenstedt; Quenstedt: 106, pl. 13, figs 27–30.  
 1925a *Arnioceras nigrum* (Blake); Spath: 329, fig. 10b (BM 50150c, possibly from bed 424.2 or 424.3).  
 1966 *Arnioceras miserabile* (Quenstedt); Guérin-Franiatte: 254, pl. 136, figs 1 (neotype, from Germany, original of Quenstedt, 1884: pl. 21, fig. 27), 2–4 (from Germany and France).  
 1976 *Arnioceras miserabile* (Quenstedt); Schlegelmilch: 49, pl. 21, fig. 5 (neotype).

RANGE. Beds 424.2–425.5, Sauzeanum Subzone; 7 specimens.

Genus *VERMICERAS* Hyatt, 1889

*Vermiceras multanfractum* (Simpson, 1855)

- 1855 *Ammonites multanfractus* Simpson: 95.  
 1962 *Vermiceras multanfractum* (Simpson); Howarth: 101, pl. 14, fig. 6 (neotype, WM 281); not found by Bairstow, possibly derived from Glacial Drift in Robin Hood's Bay.

## PLATE 1

Fig. 1 *Tragophylloceras numismale* (Quenstedt). Bed 505.2, CA 2744.

Fig. 2 *Arnioceras semicostatum* (Young & Bird). Bed 424.2, CA 2830.

Fig. 3 *Lytoceras fimbriatum* (J. Sowerby). Bed 576.4, CA 2778, × 0.6; the large outer whorl is part of the body chamber.

Fig. 4 *Asteroceras confusum* Spath. Bed 446.32, CA 3010.

Fig. 5 *Euagassicerias resupinatum* (Simpson). Bed 422.2, CA 2948.

Fig. 6 *Eparietites impendens* (Young & Bird). Bed 461, CA 3228.

Fig. 7 *Aegasteroceras sagittarium* (Blake). Bed 456, CA 3124.

Fig. 8 *Coroniceras (Arietites) alcinoe* (Reynès). Bed 429.64, CA 2803, × 0.6; the asterisk marks the probable end of the phragmocone.

All figures natural size, except Figs 3 and 8.

Where determinable the position of the end of the phragmocone is marked with an asterisk (\*) on all specimens figured in the plates.



1b



1a

\*

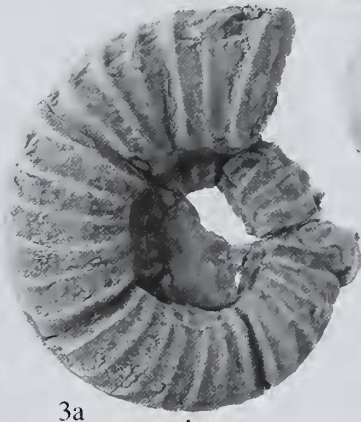


2a

\*



3b



3a

\*



4a



4b



2b



5b

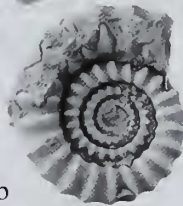


5a

\*



6b



6a

\*



7a

\*



7b



8

Subfamily **AGASSICERATINAE** Spath, 1924  
Genus **AGASSICERAS** Hyatt, 1875

Well-preserved *Agassicerias scipionianum* (d'Orbigny) and the smaller, smoother species *A. personatum* have been figured before from Robin Hood's Bay and are common in old collections, but none were found by Baird. *Agassicerias* mainly characterizes the Scipionianum Subzone, just below the lowest horizon exposed in Robin Hood's Bay, so, although it is possible that some of them came from beds 421 or 422, it is more likely that they were derived from Glacial Drift.

***Agassicerias personatum*** (Simpson, 1843)

- 1843 *Ammonites personatus* Simpson: 9.  
1920 *Agassicerias personatum* (Simpson); Buckman: pl. 187, figs 1, 2 (holotype, WM 2125), 3, 4 (paratype WM 67).

REMARKS. A small smooth species.

***Agassicerias scipionianum*** (d'Orbigny, 1844)

- 1844 *Ammonites scipionianus* d'Orbigny: 207, pl. 51, figs 7, 8.  
?1855 *Ammonites illatus* Simpson: 39 (*non Ammonites illatus* Simpson, 1843: 10).  
1876 *Arietites scipionianus* (d'Orbigny); Blake: 287, pl. 5, fig. 3 (BM C.17909; locality not recorded, but the preservation is like that of other specimens from Robin Hood's Bay).  
1961 *Agassicerias scipionianum* (d'Orbigny); Dean *et al.*: pl. 65, fig. 3 (BM 37909).  
?1962 *Agassicerias illatum* (Simpson, 1855, *non* 1843); Howarth: 102, pl. 15, fig. 1 (holotype, WM 84).  
1994 *Agassicerias scipionianum* (d'Orbigny); Fischer: 53, pl. 16, figs 1 (lectotype), 2 (both from France).

***Agassicerias decipiens*** (Spath, 1923)

- 1923b *Aetomoceras decipiens* Spath: 72.

REMARKS. Spath's three syntypes are BM C.22067a, C.22067b and a specimen at the top of the block WM 67 as figured by Buckman (1920: pl. 187, fig. 3), all from Robin Hood's Bay. Of these, C.22067a is here designated lectotype; it is similar to *A. scipionianum* (d'Orbigny), but has slightly more ribs.

Genus **EUAGASSICERAS** Spath, 1924

***Euagassicerias resupinatum*** (Simpson, 1843)

Pl. 1, fig. 5

- 1843 *Ammonites resupinatus* Simpson: 15.  
1844 *Ammonites sauzeanus* d'Orbigny: 304, pl. 95, figs 4, 5.  
1855 *Ammonites transformatus* Simpson: 91.  
1889 *Coroniceras sauzeanum* (d'Orbigny); Hyatt: 184, pl. 6, figs 4, 6–9.

- 1909 *Agassicerias resupinatum* (Simpson); Buckman: pl. 6 (holotype, WM 96; ?from bed 421 or 422).  
1913 *Agassicerias transformatum* (Simpson); Buckman: pl. 75 (holotype, WM 279, ?from bed 421 or 422).  
1913 *Defossicerias defossum* (Simpson, 1843); Buckman: pl. 76 (WM 103, a paralectotype, presumably also from beds 421–422; see Donovan & Forsey (1973: 13) for interpretation of *Defossicerias* and its type species).  
1994 *Euagassicerias sauzeanum* d'Orbigny; Fischer: 84, pl. 16, fig. 3 (holotype, from France).

RANGE. Beds 421.4–426.1, Sauzeanum Subzone; 38 specimens, of which the best preserved are in beds 421 and 422.

REMARKS. Typical examples of *Euagassicerias* occur in beds 421 and 422, and it is likely that the holotypes of Simpson's species *E. resupinatum* and *E. transformatum* are from those beds; both species are synonyms of *E. sauzeanum* (d'Orbigny, 1844), and *E. resupinatum* (Simpson, 1843) is the senior name for this species.

Subfamily **ASTEROCERATINAE** Spath 1946  
Genus **ASTEROCERAS** Hyatt, 1867

***Asteroceras obtusum*** (J. Sowerby, 1817)

- 1817 *Ammonites obtusus* J. Sowerby: 151, pl. 167.  
1966 *Asteroceras obtusum* (J. Sowerby); Guérin-Franiatte: 294, pl. 170 (lectotype, Oxford University Museum, OUM J.1194, from Charmouth, Dorset).

RANGE. One specimen in bed 446.32, Obtusum Subzone. A single *Asteroceras* sp. indet. in bed 446.31 is the lowest recorded *Asteroceras* in Robin Hood's Bay.

***Asteroceras confusum*** Spath, 1925

Pl. 1, fig. 4; Pl. 2, fig. 1

- 1880/81 *Arietites obtusus* (J. Sowerby); Wright: 293 (1881), pl. 21, figs 3, 4 (1880) (holotype of *Asteroceras confusum* Spath).  
1925a *Asteroceras confusum* Spath: 300.  
1966 *Asteroceras confusum* Spath; Guérin-Franiatte: 296, pl. 172 (holotype, BM C.2223, from Bredon, Worcestershire).

RANGE. Five specimens in beds 446.32 and 446.33, Obtusum Subzone.

REMARKS. *A. confusum* has thicker whorls and more prominent grooves bordering the keel on the venter than *A. obtusum*.

***Asteroceras stellare*** (J. Sowerby, 1815)

- 1815 *Ammonites stellaris* J. Sowerby: 211, pl. 93.  
1880/81 *Arietites stellaris* (J. Sowerby); Wright: 295 (1881), pl. 22, figs 3–5 (1880) (lectotype, BM 43969a, from Dorset).  
1882 *Aegoceras sagittarium* (Blake); Wright: 355, pl. 52, figs 1–

**PLATE 2**

**Fig. 1** *Asteroceras confusum* Spath. Bed 446.32, CA 3011, × 0.6.

**Fig. 2** *Asteroceras blakei* Spath. Bed 452, CA 2990, × 0.5.

**Figs 3, 5** *Caenisiites turneri* (J. de C. Sowerby). Bed 433.3, 3, CA 3194, 5, CA 3197; the asterisk marks the probable end of the phragmocone.

**Fig. 4** *Aegasteroceras crassum* Spath. Bed 458.2, CA 3048; a body chamber fragment.

**Fig. 6** *Gagaticeras neglectum* (Simpson). Bed 468, CA 3326; probably wholly septate.

**Fig. 7** *Gagaticeras exortum* (Simpson). Bed 468, CA 3292; the asterisk marks the probable end of the phragmocone.

**Fig. 8** *Eparietites bairstowi* sp. nov. **Paratype**, bed 455.5, CA 3218; probably wholly septate.

All figures natural size, except Figs 1 and 2.

3 (BM C.3124, a large specimen that is very similar to specimens from bed 451; it is more involute and has higher whorls than *sagittarium*).

1961 *Asteroceras stellare* (J. Sowerby); Dean *et al.*: pl. 67, fig. 2 (lectotype, BM 43969a, from Dorset).

RANGE. Beds 447–451, Stellare Subzone; 19 specimens.

REMARKS. *A. stellare* is a large species, and is more involute and has more massive whorls than *A. obtusum*.

*Asteroceras blakei* Spath, 1925 Pl. 2, fig. 2

1925a *Asteroceras blakei* Spath: 264, fig. 5 (holotype, BM C.19991; from beds 452–455.4, probably 452–53).

1925a *Asteroceras marstonense* Spath: 267, fig. 7 (holotype, BM 37948, probably from bed 452 or 453).

RANGE. Beds 452–455.4, Stellare and Denotatus Subzones; 29 specimens.

REMARKS. *A. blakei* occurs at a higher stratigraphical level, and is more involute and more compressed than *A. obtusum*. *A. marstonense* is a synonym, and its holotype comes from Robin Hood's Bay despite being named after Marston Magna, Somerset.

Genus *AEGASTEROCERAS* Spath, 1925

*Aegasteroceras sagittarium* (Blake, 1876) Pl. 1, fig. 7

1876 *Aegoceras sagittarium* Blake: 276, pl. 7, figs 2A (lectotype, SM J18230), 2B (paralectotype, BM C.17881).

1880/82 *Aegoceras acuticostatum* Wright: 371 (1882), pl. 35, figs 1–3 (1880) (holotype, SM J18230); objective synonym of *Aegoceras sagittarium* Blake, 1876.

1882 *Aegoceras sagittarium* Blake; Wright: 355, pl. 52, figs 4, 5 (BM C.1873); pl. 52A, figs 3, 4 (BM C.1873), 5 (BM C.1874), 6 (BM C.1875).

1925a *Aegasteroceras simile* Spath: 265, fig. 6a (holotype, BM C.26687).

1966 *Aegasteroceras simile* Spath; Guérin-Franiatte: 310, pl. 189 (BM C.26687).

1966 *Aegasteroceras sagittarium* (Blake); Guérin-Franiatte: 312, pl. 192, fig. 1 (SM J18230).

RANGE. Beds 454.1–458.1, Stellare and Denotatus Subzones; 123 specimens; all the figured ones are from beds 454.2 or 456, probably the latter.

*Aegasteroceras crassum* Spath, 1925 Pl. 2, fig. 4

1882 *Aegoceras sagittarium* Blake; Wright: 355, pl. 52A, figs 1, 2 (BM C.1922, from bed 458.2 or 458.3, holotype of *Aegasteroceras crassum* Spath, 1925).

1925a *Aegasteroceras crassum* Spath: 266.

RANGE. Beds 449–458.3, Stellare and Denotatus Subzones; 9 specimens.

Genus *CAENISITES* Buckman, 1925

*Caenisites turneri* (J. de C. Sowerby, 1824) Pl. 2, figs 3, 5

1824 *Ammonites turneri* J. de C. Sowerby: 75, pl. 452, upper figure.

1879/81 *Arietites turneri* (J. de C. Sowerby); Wright: 292 (1881), pl. 12, fig. 4 (1879) (lectotype, BM 43973a, from Glacial Drift, Norfolk).

1956 *Euasteroceras tumeri* (J. de C. Sowerby); Arkell: 760, pl. 31, fig. 1 (BM 43973a).

1961 *Caenisites turneri* (J. de C. Sowerby); Dean *et al.*: pl. 66, fig. 2 (from Bredon Hill, Worcestershire).

RANGE. From beds 433.3 and 435, Birchi Subzone; 26 specimens.

*Caenisites brooki* (J. Sowerby, 1818)

1818 *Ammonites brooki* J. Sowerby: 203, pl. 190.

1961 *Caenisites brooki* (J. Sowerby); Dean *et al.*: pl. 66, fig. 1 (BM C.5606, from Charmouth, Dorset).

1966 *Caenisites brooki* (J. Sowerby); Guérin-Franiatte: 325, pl. 210 (holotype, OUM J.16020, from Lyme Regis, Dorset).

RANGE. From beds 431.2–433.3, Brooki and Birchi Subzones; 11 specimens.

REMARKS. One of those from bed 431.3 is notable in being extremely large: before removal from the rock, it was measured by Bairstow as 585 mm diameter. The outer part was not recovered, but the portion now preserved in the collection is 445 mm diameter and has a massive, almost smooth outer half whorl with keel and grooves on the venter. The inner whorls are covered in matrix and probably crushed.

Genus *EPARIETITES* Spath, 1924

*Eparietites impendens* (Young & Bird, 1828)

Pl. 1, fig. 6; Pl. 4, fig. 1

1828 *Ammonites impendens* Young & Bird: 266.

1855 *Ammonites denotatus* Simpson: 76.

1855 *Ammonites tenellus* Simpson: 97.

1876 *Arietites impendens* (Young & Bird); Blake: 290, pl. 6, fig. 7 (BM C.17936).

1878/81 *Arietites collenoti* (d'Orbigny); Wright: 304 (1881), pl. 6 (1878), fig. 1 (BM C.1881; probably from bed 464.32), pl. 22B, figs 1–3 (holotype of *Ammonites denotatus*, SM J3273).

1912 *Arietites tenellus* (Simpson); Buckman: pl. 54 (holotype, WM 293, probably from bed 461 or 464.32).

1912 *Arietites denotatus* (Simpson); Buckman: pls 67A, B (holotype, SM J3273).

1919 *Arietites impendens* (Young & Bird); Buckman: pl. 120 (holotype, WM 292, from bed 462 or 464.1).

1961 *Eparietites denotatus* (Simpson); Dean *et al.*: pl. 66, fig. 4 (BM C.17936).

RANGE. Beds 457–464.32, Denotatus and Simpsoni Subzones; 57 specimens; all the figured specimens are from beds 461–464.

REMARKS. Both *denotatus* and *tenellus* are synonyms of *E. impendens*; the best type specimen is the holotype of Simpson's *denotatus*, but it is clearly the same as the holotype of Young & Bird's *impendens*, and the holotype of *tenellus* differs only in having the crushed-flat type of preservation that is common at some horizons.

*Eparietites bairstowi* sp. nov.

Pl. 2, fig. 8; Pl. 3

HOLOTYPE. CA 3217, from bed 455.2, lower part of Denotatus Subzone.

PARATYPES. CA 3218 and 3219, from bed 455.5, lower part of Denotatus Subzone.

DIAGNOSIS. An evolute species of *Eparietites* in which the umbili-

cal width is 38–40% of the diameter; the whorls are quickly expanding and massive, the whorl breadth is large, and the venter is tricarinate-bisulcate, but loses the sulci at the largest sizes; inner whorls have radial ribs and small ventro-lateral tubercles, but all ornament fades by 230 mm diameter.

**DESCRIPTION.** Before removal from the rock, Bairstow measured the holotype as having a crushed outer whorl ending at 480 mm ('19 inches') diameter. At that size it was probably complete, but the part he collected in 1933 is solid and uncrushed up to the end of the phragmocone at 330 mm diameter, followed by a short portion at the beginning of the crushed body-chamber ending at about 350 mm diameter. Slightly more than one whorl up to the end of the phragmocone is preserved, to which is attached a small portion of the upper part of the side of the next inner whorl. These whorls are massive, rapidly expanding, moderately evolute, and have a whorl section in which the whorl sides converge slightly towards the tricarinate-bisulcate venter, which has a strong central keel. Moderately strong radial ribs fade and disappear three-quarters of a whorl before the end of the phragmocone, and the remaining whorls are smooth.

The larger paratype (CA 3218) consists of inner whorls up to 40 mm diameter, but only a quarter of a whorl up to 25 mm is well preserved. This has quadrate, moderately evolute whorls with a tricarinate-bisulcate venter, and strong straight radial ribs up to small ventro-lateral tubercles; the ribs then bend strongly forwards on the side of the venter and join the lateral keels.

The smaller paratype (CA 3219) consists of small inner whorls up to only 12.5 mm diameter. Its whorl shape, ribs and tubercles are similar to those of the larger paratype.

#### MEASUREMENTS (in mm)

	D	Wh	Wb	U
CA 3217	342	116 (0.34)	90 (0.26)	136 (0.40)
CA 3217	265	92 (0.35)	67 (0.25)	101 (0.38)

**REMARKS.** This is the oldest *Eparietites* and is more evolute than any of the succeeding species. The large holotype has massive whorls, with a quadrate whorl section in which the whorl sides converge only slightly towards the venter, a large whorl breadth, and a tricarinate-bisulcate venter; the sulci bordering the central keel on the venter slowly disappear at the largest sizes. *E. impendens* occurs higher up at Robin Hood's Bay and has much more compressed and involute whorls, the umbilical width being 22–24% of the diameter compared with 38–40% in *E. bairstowi*.

Many *Eparietites* occur in the Denotatus Subzone in the top 0.5 m of the Frodingham Ironstone at Scunthorpe, Lincolnshire. Specimens attain very large sizes, some in the NHM collections being up to 600 mm diameter. Most of the smaller specimens are *E. impendens*, but the larger specimens belong mainly to the more evolute species *Eparietites undaries* (Quenstedt), in which the umbilical width is 27–34% of the diameter (Guérin-Franiatte, 1966: 319). There is also one good example of *E. bairstowi* in the Frodingham Ironstone: it is a quarter whorl uncrushed fragment, wholly septate, with a whorl height and breadth of 103.5 and 69.3 mm respectively, and is closely similar to the Robin Hood's Bay holotype at the same size.

Genus *EPOPHIOCERAS* Spath, 1924

#### *Epophioceras landrioti* (d'Orbigny, 1849)

- 1849 *Ammonites landrioti* d'Orbigny: 213.  
1907 *Ammonites landrioti* d'Orbigny; Thevenin: 94, pl. 7, figs 4, 5 (holotype, from the Obtusum Zone, France).

- 1966 *Epophioceras landrioti* (d'Orbigny); Guérin-Franiatte: 329, pl. 217 (holotype).

**RANGE.** Beds 446.5–448.11, Obtusum and Stellare Subzones; 3 specimens. A single *Epophioceras* sp. indet. was found in bed 446.4.

Family **ECHIOCERATIDAE** Buckman, 1913

Genus **PALAEOECHIOCERAS** Spath, 1929

#### *Palaeoechioceras* sp. indet.

- 1973 *Palaeoechioceras* sp.; Getty: 9, pl. 1, figs 1 (BM C.79680), 5 (BM C.79678), 9 (BM C.79679); all from bed 467.

**RANGE.** Bed 467, Simpsoni Subzone; 3 specimens.

Genus **GAGATICERAS** Buckman, 1913

**REMARKS.** In Robin Hood's Bay examples of *Gagaticeras* are found only in beds 467–470, the top half of the Simpsoni Subzone. Although they are divided here into *G. neglectum* with medium to coarse ribs, *G. finitimum* with finer ribs, *G. exortum* with strongly rursiradiate ribs, and *G. gagateum* with markedly depressed whorls, larger collections of better specimens might suggest that there are fewer than four species present.

#### *Gagaticeras gagateum* (Young & Bird, 1828)

- 1828 *Ammonites gagateus* Young & Bird: 255, pl. 12, fig. 7.  
1876 *Aegoceras gagateum* (Young & Bird); Blake: 275, pl. 6, fig. 8 (BM C.17883, from bed 467).  
1880/82 *Aegoceras gagateum* (Young & Bird); Wright: 364, pl. 37, figs 8, 9 (BM C.2228, probably from bed 467).  
1913 *Gagaticeras gagateum* (Young & Bird); Buckman: pl. 78 (holotype, WM 104, from bed 467).  
1919 *Gagaticeras funiculatum* Buckman: pl. 122 (holotype, BM C.41783).  
1962 *Gagaticeras gagateum* (Young & Bird); Howarth: 102, pl. 14, fig. 6 (WM 744, paratype of *Ammonites multianfractus* Simpson, 1855).  
1976 *Gagaticeras gagateum* (Young & Bird); Schlegelmilch: 138, pl. 21, fig. 7 (WM 104).

**RANGE.** Occurs only in bed 467, Simpsoni Subzone; 2 specimens; has strongly depressed whorls.

#### *Gagaticeras exortum* (Simpson, 1855) Pl. 2, fig. 7

- 1855 *Ammonites exortus* Simpson: 44.  
1855 *Ammonites integricostatus* Simpson: 46.  
1910 *Echioceras exortum* (Simpson); Buckman: pl. 19, figs 2, 3 (neotype (designated Howarth, 1962: 106), WM 645).  
1912 *Androgynoceras integricostatum* (Simpson); Buckman: pl. 47 (holotype, WM 92).

**RANGE.** Beds 467–70, Simpsoni Subzone; 15 specimens; characterized by markedly rursiradiate ribbing.

#### *Gagaticeras neglectum* (Simpson, 1855) Pl. 2 fig. 6

- 1855 *Ammonites neglectus* Simpson: 45.  
1914 *Parechioceras neglectum* (Simpson); Buckman: pl. 101 (holotype, WM 98).  
1976 *Gagaticeras neglectum* (Simpson); Schlegelmilch: 138, pl. 21, fig. 8 (WM 98).

RANGE. Beds 467-70, Simpsoni Subzone; 77 specimens; the holotype came from bed 468 or 470; has medium to coarse ribbing.

*Gagaticeras finitimum* (Blake, 1876)

1876 *Aegoceras* (?) *finitimum* Blake: 273, pl. 6, fig. 9.

1914 *Parechioceras finitimum* (Blake): Buckman: pl. 100A (holotype, SM J3280, possibly from bed 468).

RANGE. Beds 467 and 468, Simpsoni Subzone; 11 specimens; finely ribbed.

Genus *ECHIOCERAS* Bayle, 1878

*Echioceras raricostatum* (Zieten, 1831)

1831 *Ammonites raricostatus* Zieten: 18, pl. 13, fig. 4.

1855 *Ammonites cereus* Simpson, 1855: 47.

1912 *Echioceras cereum* (Simpson); Buckman: pl. 49 (holotype, WM 461).

1973 *Echioceras raricostatum* (Zieten); Getty: 13, pl. 1, fig. 7 (neotype, designated Getty, from Württemberg, Germany).



PLATE 3

*Eparietites bairstowi* sp. nov. Holotype, bed 455.2, CA 3217,  $\times 0.48$ .

REMARKS. Examples of *Echioceras* with strongly depressed whorls and coarse ribs were not found by Bairdow, and the horizon of Simpson's holotype WM 461 is not known; presumably it ought to have come from the *Raricostatoides* Subzone.

*Echioceras raricostatoides* (Vadasz, 1908) Pl. 4, fig. 2

- 1908 *Arietites raricostatoides* Vadasz: 373.  
 1925 *Echioceras fulgidum* Trueman & Williams: 717, pl. 1, fig. 12 (BM C.17424, possibly from bed 489).  
 1973 *Echioceras raricostatoides* (Vadasz); Getty: 13, pl. 1, fig. 12 (neotype, designated by Getty, from Nancy, France).

RANGE. Beds 488–491.1, *Raricostatoides* Subzone; 15 specimens.

REMARKS. The very well preserved specimen from bed 489 figured in Pl. 4, fig. 2 has a closely similar rib-density to that of the neotype shown in Getty's (1973: 15, fig. 3) graph. The more densely ribbed species *E. aeneum* Trueman & Williams, *Echioceras laevodolum* (Quenstedt; Schlegelmilch, 1976: pl. 21, fig. 12, lectotype) which has modified ribbing at large whorl sizes, and *E. pauli* (Dumortier, 1867: pl. 29, figs 5, 6), all said to occur in the lowest part of the *Raricostatoides* Subzone by Getty (1973: 14), were not identified amongst Bairdow's material.

*Echioceras intermedium* (Trueman & Williams, 1925)

- 1925 *Pleurechioceras intermedium* Trueman & Williams: 720, pl. 2 fig. 2 (holotype, BM C.26787, from bed 493).  
 1973 *Echioceras intermedium* (Trueman & Williams); Getty: 16, pl. 3, fig. 1 (BM C.79684, from bed 493).

RANGE. Beds 491.2 and 493.2, *Raricostatoides* Subzone; 7 specimens.

Genus *LEPTECHIOCERAS*, Buckman 1923

*Leptechioceras macdonnelli* (Portlock, 1843)

- 1843 *Ammonites macdonnelli* Portlock: 134, pl. 29A, fig. 12.  
 1880/81 *Arietites nodotianus* (d'Orbigny); Wright: 301 (1881), pl. 37, figs 3, 4 (1880) (holotype of *Ammonites macdonnelli* Portlock, from Larne, northern Ireland, Ulster Museum no. K8117).  
 1923 *Leptechioceras macdonnelli* (Portlock); Buckman: pl. 443 (BM C.41756, from Cheltenham).  
 1961 *Leptechioceras macdonnelli* (Portlock); Dean *et al.*: pl. 67, fig. 6 (BM C.41756, from ?Larne, Co Antrim, northern Ireland).  
 1973 *Leptechioceras macdonnelli* (Portlock); Getty: 16.

RANGE. Beds 494–495.7, *Macdonnelli* Subzone; 5 specimens.

REMARKS. The earliest examples in bed 494 are identified as *L. aff. macdonnelli* because reduced ribbing persists onto their outer whorls, which do not become as smooth as in the later specimens from beds 495.13 and 495.7. Nevertheless, in those early specimens the ribs are more reduced than in *L. nodotianum* (d'Orbigny, 1843; Fischer, 1994: 48, pl. 20, fig. 4, holotype), *L. charpentieri* (Schafhautl, 1847; Getty, 1973: pl. 2, fig. 6, lectotype) or *L. meigeni* (Hug, 1899), all of which are more strongly ribbed throughout.

Genus *PALTECHIOCERAS* Buckman, 1924

*Paltechioceras planum* (Trueman & Williams, 1925)

- 1925 *Leptechioceras planum* Trueman & Williams: 731, pl. 2, fig. 5 (holotype, from Radstock, Somerset).

- 1926 *Leptechioceras planum* Trueman & Williams; Buckman: pl. 696 (holotype refigured).

RANGE. Beds 493.3–493.5, *Raricostatoides* Subzone; 5 specimens.

*Paltechioceras tardecrescens* (Hauer, 1856)

Pl. 4, figs 3, 6

- ?1855 *Ammonites aureolus* Simpson: 94.  
 1856 *Ammonites tardecrescens* Hauer: 20, pl. 3, figs 10–12.  
 1876 *Arietites tardecrescens* (Hauer); Blake: 285, pl. 5, figs 5 (?BM C.17879, from bed 498), 5b (?BM C.17898).  
 1889 *Caloceras aplanatum* Hyatt: 146, figs 23, 24 (on p. 147).  
 1889 *Amioceras tardecrescens* (Hauer); Hyatt: 168, pl. 2, fig. 19.  
 ?1914 *Echioceras aureolum* (Simpson); Buckman: pl. 96 (lectotype, designated by Donovan (1958: 24), GSM 26402, from bed 497); ?senior synonym of *P. tardecrescens*.  
 1926 *Metechioceras aplanatum* (Hyatt); Buckman: pl. 640 (holotype, MCZ 80 (Museum of Comparative Zoology, Cambridge, Massachusetts), from bed 498).  
 1961 *Paltechioceras aplanatum* (Hyatt); Dean *et al.*: pl. 68, fig. 2 (BM 37999, from bed 498).  
 1973 *Paltechioceras aplanatum* (Hyatt); Getty: 21, pl. 4, fig. 1 (BM C.17898, from bed 498).  
 1973 *Paltechioceras tardecrescens* (Hauer); Getty: 21, pl. 4, fig. 2 (lectotype, designated Getty, from Adneth, Salzburg, Austria).  
 1992 *Paltechioceras tardecrescens* (Hauer); Dommergues & Meister: 221, figs 5(1)–5(4) (from bed 497).

RANGE. Beds 497–499, *Aplanatum* Subzone; 228 specimens.

REMARKS. *P. tardecrescens* is abundant in beds 497 and 498; those in bed 498 are up to 175 mm diameter and are preserved in limestone nodules (Pl. 4, fig. 6), and many of the previously figured specimens undoubtedly came from this bed (including the holotype of Hyatt's species *aplanatum*). Most of the specimens in bed 497 are much smaller pyritized whorls up to about 40 mm diameter (Pl. 4, fig. 3), though there are a few crushed and partly pyritized fragments of larger whorls up to 90 mm diameter. The lectotype of *P. aureolum* (Simpson, 1855; Buckman, 1914: pl. 96) is pyritized like most specimens in bed 497 and can be matched closely with several of them (eg. CA 3456 and 3480); it is only 25 mm diameter, but *Ammonites aureolus* Simpson, 1855, might be a senior synonym of *Paltechioceras tardecrescens* (Hauer, 1856). In addition, two specimens were found at the base of bed 499 and 0.08 m above the base of that bed respectively.

*Paltechioceras regustatum* Buckman, 1914

- 1911 *Echioceras aureolum* (Simpson); Buckman: pl. 28 (paralectotype of *Ammonites aureolus* Simpson, WM 872, from bed 497).  
 1914 *Paltechioceras regustatum* Buckman: 96c.  
 1973 *Paltechioceras aureolum* (Simpson); Getty: 20, pl. 5, figs 3 (holotype of *Echioceras regustatum* Buckman, GSM 26439, from bed 496 or 497), 4 (BM C.79681, from bed 497).

RANGE. Beds 496 and 497, *Aplanatum* Subzone; 18 specimens.

REMARKS. *P. regustatum* is the second and less common species of *Paltechioceras* in the *Aplanatum* Subzone, and is represented by a few poorly preserved specimens in bed 496 and two in bed 497; it has much more widely spaced ribs than *P. tardecrescens* at diameters of more than 25 mm. Two larger examples figured by Getty (1973: pl. 5, figs 3, 4) as *P. aureolum* are 50 and 64 mm diameter respectively, and the latter



1a



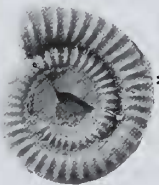
1b



2b



2a



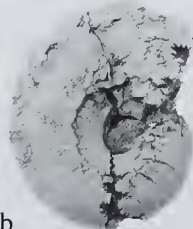
3a



3b



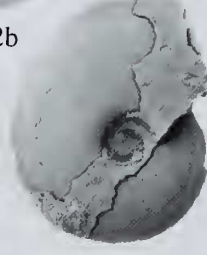
4b



4a



5b



5a



6a



6b



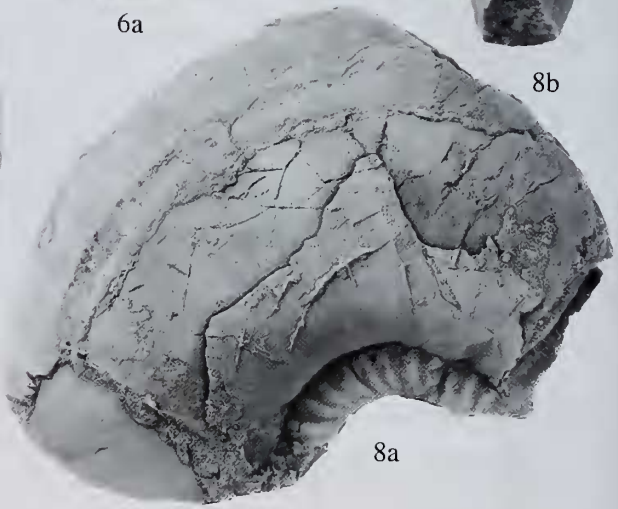
8b



7b



7a



8a



was said to be from bed 497 (Getty, 1973: 20, 'Tate & Blake's Jamesoni Zone bed 60'). The former of Getty's specimens is the holotype of *P. regustatum* (Buckman, 1914), and this seems to be the correct specific name for the less densely ribbed *Paltechioceras* in beds 496 and 497, because the lectotype of *P. aureolum* has the same rib density as in *P. tardecrescens*, of which it might be a senior synonym.

Family **OXYNOTICERATIDAE** Hyatt, 1867  
Genus **OXYNOTICERAS** Hyatt 1867

REMARKS. Determination of species of *Oxynoticeras* in the Simpsoni Subzone presents many problems: Simpson (1843, 1855) proposed the specific names *simpsoni*, *limatus*, *bucki*, *flavus* and *lens*, and Spath (1925a) proposed the name *eboracense*, all for specimens from beds 467 or 468 (the type specimens of *aliaenum* and *dejectum*, both of Simpson, 1855, are lost and the names are not usable). The name *simpsoni* has date and page priority, and is frequently used for these ammonites. However, Spath's *eboracense* also has a well-preserved type specimen, and if this represents a species different from *O. simpsoni*, then it differs only by its more compressed whorls up to 40 mm diameter. But the many examples of *Oxynoticeras* in beds 467 and 468 show a large amount of variation in whorl compression and rib strength on whorls up to 50 mm diameter, and there are no larger ammonites that can be identified as *O. 'eboracense'* in having more compressed whorls than *O. simpsoni* at large sizes. *O. bucki* (Simpson, 1843) and *O. lens* (Simpson, 1855) are clearly the same as *O. eboracense*, of which they are senior synonyms; *O. flavum* and *O. limatum*, both of Simpson, 1843, are smaller and have slightly thicker whorls like those of *O. simpsoni*. The lectotype of *O. collenoti* (d'Orbigny, 1844; figured by Fischer, 1994: 85, pl. 17, fig. 3) is also very similar to the types of *lens* and *eboracense*.

Larger collections of better preserved specimens will be needed to determine whether these *Oxynoticeras* can really be divided into more than one species, so in this paper all the specimens in beds 463–472.1 are identified as *O. simpsoni*.

*Oxynoticeras simpsoni* (Simpson, 1843) Pl. 4, figs 5, 8

- 1843 *Ammonites simpsoni* Simpson: 37.  
1843 *Ammonites limatus* Simpson: 41.  
1843 *Ammonites bucki* Simpson: 42.  
1843 *Ammonites flavus* Simpson: 43.  
?1855 *Ammonites lens* Simpson: 80.  
1876 *Amaltheus simpsoni* (Simpson); Blake: 291, pl. 8, fig. 4 (BM C.17903).  
1881/82 *Amaltheus simpsoni* (Bean); Wright: 392 (1882), pl. 47 (1881), figs 4, 5 (SM J18231), 6, 7 (SM J18232).  
1912 *Oxynoticeras flavum* (Simpson); Buckman: pl. 55 (holotype, WM 481).

- 1912 *Oxynoticeras limatum* (Simpson); Buckman: pl. 56, fig. 1 (holotype, WM 480).  
1912 *Aetomoceras simpsoni* (Simpson); Buckman: pls 66A, B (holotype, WM 813).  
1920 *Oxynoticeras bucki* (Simpson); Buckman: pl. 165A (holotype, WM 479a).  
1925a *Oxynoticeras eboracense* Spath: 108, 110, figs d, e (holotype, BM C.18060).  
1925a *Oxynoticeras simpsoni* (Simpson); Spath: 110, figs f, g (BM 37998).  
1961 *Oxynoticeras simpsoni* (Simpson); Dean *et al.*: pl. 67, fig. 4 (BM C.17903).  
?1962 *Gleviceras lens* (Simpson); Howarth: 105, pl. 15, fig. 3 (holotype, GSM 26405).  
1976 *Oxynoticeras bucki* (Simpson); Schlegelmilch: 140, pl. 22, fig. 12 (WM 479a).

RANGE. Beds 463–470, Simpsoni Subzone; 63 specimens.

REMARKS. All the figured specimens listed in the synonymy above probably came from beds 467 or 468. *O. simpsoni* is a distinctive species that has a larger umbilicus and thicker whorls than *O. oxynotum* and similar species. In Robin Hood's Bay it overlaps in stratigraphical range with *Eparietites impendens*, from which it differs mainly in whorl section; *E. impendens* has a differentiated ventral keel, flanked by narrow flat areas then angled ventro-lateral shoulders, and a vertical umbilical wall and rounded umbilical edge; in *O. simpsoni* the venter is either lanceolate or fastigate with no angles at the umbilical shoulders and without a differentiated keel, and the broad umbilical wall typically slopes at a low angle and merges gradually into the side of the whorl. *E. impendens* has ribs at least on the inner whorls; most *O. simpsoni* are smooth, though some early examples retain ribs on small inner whorls.

The lowest *O. simpsoni* with no ventro-lateral angles at the side of the keel occurs in bed 463, where there are two large examples: one is part of a solid body-chamber ending at about 340 mm diameter; the other is 380 mm diameter and has half a whorl of body-chamber, but is crushed and less well-preserved. A large fragment from bed 464.33 is septate up to at least 256 mm diameter. A smaller *O. simpsoni* from bed 464.32 is figured in Pl. 4, fig. 8, which has ribbing on its inner whorl at about 80 mm diameter, and a small specimen from bed 468 is also figured (Pl. 4, fig. 5).

*Oxynoticeras oxynotum* (Quenstedt, 1843) Pl. 4, fig. 4

- 1843 *Ammonites oxynotus* Quenstedt: 161.  
1843 *Ammonites polyophyllus* Simpson: 39.  
1845 *Ammonites oxynotus* Quenstedt; Quenstedt: 98, pl. 5, fig. 11 (holotype).  
1884 *Ammonites oxynotus* Quenstedt; Quenstedt: 175, pl. 22, fig. 29 (holotype).  
1909 *Oxynoticeras polyophyllum* (Simpson); Buckman: pl. 8 (holotype, WM 739).

PLATE 4

Fig. 1 *Eparietites impendens* (Young & Bird). Bed 462, CA 3243.

Fig. 2 *Echioceras raricostatoides* Vadasz. Bed 489, CA 3393; wholly septate.

Figs 3, 6 *Paltechioceras tardecrescens* (Hauer). 3, bed 497, CA 3572. 6, bed 498, CA 3616; probably wholly septate.

Fig. 4 *Oxynoticeras oxynotum* (Quenstedt). Bed 481, CA 3716; wholly septate.

Figs 5, 8 *Oxynoticeras simpsoni* (Simpson). 5, bed 468, CA 3692; wholly septate. 8, bed 464.32, CA 3652, × 0.8; the outer whorl is part of the body chamber.

Fig. 7 *Gleviceras doris* (Reynès). Bed 476, CA 3726, × 0.6.

All figures natural size, except Figs 7 and 8.

- 1961 *Oxynoticeras oxynotum* (Quenstedt); Dean *et al.*: pl. 66, fig.5 (holotype, Geol.-Pal. Institut, Tübingen, from Württemberg, Germany).

RANGE. Beds 472.1–481, Oxynotum Subzone; 4 specimens.

REMARKS. The lowest *Oxynoticeras* that are more involute and flat-whorled than *O. simpsoni* occur in bed 472.1, which is therefore the base of the Oxynotum Subzone. Better preserved *O. oxynotum* occur higher up in beds 475.3 and 481 (Pl. 4 fig. 4), and there are several fragments of *Oxynoticeras* sp. indet. from beds 480, 482 and 483 consisting of large compressed whorls up to 260 mm diameter that have acute venters and complex suture-lines.

### Other species of *Oxynoticeras*:

?*Oxynoticeras aliaenum* (Simpson, 1855: 85).

?*Oxynoticeras dejectum* (Simpson, 1855: 85).

The type specimens of both Simpson's species are lost, and the species are not identifiable.

Genus *GLEVICERAS* Buckman, 1918

*Gleviceras doris* (Reynès, 1879) Pl. 4, fig. 7

1879 *Ammonites doris* Reynès: pl. 41, figs 13–15 (probably from France).

1914 *Oxynoticeras doris* (Reynès); Pia: 7, 30, pl. 1, fig. 1; pl. 8, fig. 1.

RANGE. Beds 476 and 485.2, Oxynotum Subzone; 3 specimens.

*Gleviceras guibalianum* (d'Orbigny, 1844)

1844 *Ammonites guibalianus* d'Orbigny: 259, pl. 73, figs 1–4.

1973 *Gleviceras subguibalianum* (von Pia) (*sic*); Donovan & Forsey: 9, pl. 2, fig. 1 (lectotype of *Ammonites guibalianus* d'Orbigny, designated by Donovan & Forsey, from Nantua, France).

1994 *Gleviceras guibalianum* (d'Orbigny); Fischer: 66, pl. 17, fig. 2 (lectotype refigured).

RANGE. Beds 484.1–499, Oxynotum to Aplanatum Subzones; 14 specimens.

REMARKS. Most specimens are large body-chambers, or fragments thereof, up to 300 mm diameter.

Genus *PARACYMBITES* Trueman & Williams, 1927

*Paracymbites dennyi* (Simpson, 1843)

1843 *Ammonites dennyi* Simpson: 9.

1843 *Ammonites arctus* Simpson: 10.

1909 *Oxynoticeras dennyi* (Simpson); Buckman: pl. 7, figs 1 (lectotype, WM 470), 2, 3 (two paralectotypes).

1911 *Oxynoticeras arctum* (Simpson); Buckman: pl. 36 (holotype, WM 471).

1966 *Paracymbites dennyi* (Simpson); Donovan: 315, pl. 53, figs 5–12 (from Oxfordshire and Gloucestershire).

REMARKS. As revised by Donovan (1966), the holotype of this species should have come from the lower part of the *Raricostatum* Zone in Robin Hood's Bay, but no examples were found by Bairstow.

Genus *PAROXYNOTICERAS* von Pia, 1914

*Paroxynoticeras salisburgense* (Hauer, 1856)

1856 *Ammonites salisburgensis* Hauer: 47, pl. 13, figs 1–3 (lectotype, designated Donovan & Forsey (1973: 9), from Adneth, Austria).

1914 *Paroxynoticeras salisburgense* (Hauer); Pia: 18, 73, pl. 1, fig. 2; pl. 7, fig. 22; pl. 13, fig. 12.

RANGE. Two probable examples of this species were found in bed 474.3, Oxynotum Subzone.

Genus *RADSTOCKICERAS* Buckman, 1918

REMARKS. As well as the two species described below, two very large fragments of *Radstockiceras* sp. indet. were found in beds 544.4 and 544.6; both are about 350 mm diameter and one of them is septate up to about 300 mm diameter; a poorly preserved specimen was also found in bed 548.

In their revision of the holotype of *Radstockiceras buvigneri*, Donovan & Guérin-Franiatte (in Fischer, 1994: 68) said that *Radstockiceras* was a late oxynoticeratid that appeared in the Jamesoni Zone (from the evidence of Tutchter & Trueman, 1925: 598, 642) and was not present in the *Raricostatum* Zone (which was the supposed horizon at Radstock of Buckman's (1918: 288) holotype of the type species of *Radstockiceras*). However, the four large examples from bed 494 described below are a genuine record of *Radstockiceras* from the Macdonnelli Subzone, *Raricostatum* Zone, whatever may be held to be their specific determination.

### PLATE 5

Fig. 1 *Radstockiceras buvigneri* (d'Orbigny). Bed 494, CA 3744,  $\times 0.6$ ; wholly septate.

Fig. 2 *Xiphoceras dudressieri* (d'Orbigny). Bed 446.33, C.49336; the asterisk marks the probable end of the phragmocone.

Fig. 3 *Promicroceras planicosta* (J. Sowerby). Bed 451, CA 3927.

Fig. 4 *Radstockiceras sphenonotum* (Monke). Bed 544.4, CA 3758; wholly septate.

Fig. 5 *Xiphoceras ziphus* (Zieten). Bed 451, CA 3784; wholly septate.

Fig. 6 *Cymbites laevigatus* (J. de C.Sowerby). Bed 448.1, CA3763; 6a, b,  $\times 1$ ; 6c, d,  $\times 3$ ; the last septa at the position shown are approximated and probably adult.

Fig. 7 *Microderoceras birchi* (J. Sowerby). Bed 433.3, CA 3977,  $\times 0.5$ ; a complete (?adult) specimen with a body chamber nearly  $1\frac{1}{2}$  whorls long.

Fig. 8 *Apoderoceras subtriangulare* (Young & Bird). Bed 501.1, CA 3981; a septate fragment.

Fig. 9 *Eoderoceras armatum* (J. Sowerby). Neotype, probably from bed 497, C.67323,  $\times 0.75$ .

All figures natural size, except Figs 1, 6c, 6d, 7 and 9.



***Radstockiceras buvigneri*** (d'Orbigny, 1844) Pl. 5, fig. 1

- 1844 *Ammonites buvigneri* d'Orbigny: 261, pl. 74, figs 1–3.  
 1855 *Ammonites complanosus* Simpson: 79, 80.  
 1855 *Ammonites retentus* Simpson: 84.  
 1920 *Retenticeras retentum* (Simpson); Buckman: pl. 166 (holotype, GSM 26401).  
 1962 *Metoxynoticeras complanosum* (Simpson); Howarth: 105, pl. 15, fig. 4 (holotype, WM 239, now lost).  
 1992 *Radstockiceras complanosum* (Simpson); Schlegelmilch: 60, pl. 54, fig. 2 (WM 239).  
 1994 *Radstockiceras buvigneri* (d'Orbigny); Fischer: 67, pl. 21, fig. 3 (holotype, from Breux, Meuse, France).

REMARKS. Occurs in beds 494, Macdonnelli Subzone, 505.2, Taylori Subzone, and 544.7, Brevispina Subzone; 7 specimens.

## MEASUREMENTS (in mm)

	D	Wh	Wb	U
CA 3744	167.0	94.5 (0.57)	42.0 (0.25)	7.0 (0.04)
CA 3744	138.5	79.0 (0.57)	33.5 (0.24)	6.3 (0.05)

REMARKS. The four examples obtained from bed 494 are all large specimens of 145–250 mm diameter preserved in grey limestone. The best one (Pl. 5, fig. 1) is wholly septate up to its maximum size of 168 mm diameter. The single specimen from bed 505.2 is a well-preserved fragment of a part of a whorl, with whorl height 72 mm and whorl breadth 27 mm (if the whorl height is 0.57 of the diameter, then the whorl breadth is 0.21 of the diameter). One of the two pyritized specimens found in bed 544.7 is 25 mm diameter and is similar to the holotype of '*Retenticeras retentum*' figured by Buckman (1920: pl. 166). With their very small umbilici (4–5% of the diameter) and compressed whorl sections (whorl breadth 21–25% of the diameter), all appear to be genuine examples of *Radstockiceras buvigneri*, of which the holotype (Fischer, 1994: 67, pl. 21, fig. 3 – 178 mm diameter, 99 (0.56), 37 (0.21), 6 (0.03)) has closely similar characters. The holotype of Simpson's species *complanosum*, and the almost identical specimen BM 37960 (from Robin Hood's Bay), undoubtedly belong to the same species, but it is difficult to identify their horizons – they could have come from any of the beds 494, 505 and 544.

***Radstockiceras sphenonotum*** (Monke, 1888) Pl. 5, fig. 4

- 1888 *Ammonites sphenonotus* Monke: 228, pl. 2/3, fig. 14 (holotype, from Germany).  
 1914 *Oxynoticeras sphenonotum* (Monke); Pia: 65, pl. 7, fig. 12.

RANGE. Beds 542.1–544.4, Polymorphus Subzone; 8 specimens.

REMARKS. The best preserved specimen occurs in bed 544.4 (Pl. 5, fig. 4).

## Family CYMBITIDAE Buckman, 1919

## Genus CYMBITES Neumayr, 1979

***Cymbites laevigatus*** (J. de C. Sowerby, 1827) Pl. 5, fig. 6

- 1827 *Ammonites laevigatus* J. de C. Sowerby: 135, pl. 570, fig. 3.  
 1957 *Cymbites laevigatus* (J. de C. Sowerby); Donovan: 413, figs 1–8 (topotypes (the holotype is lost), from Brooki to Stellare Subzones, Dorset coast).

RANGE. Beds 446.5–464.1, top Obtusum to Simpsoni Subzones;

15 specimens; 2 specimens of *Cymbites* sp. indet. occur slightly higher in beds 464.32 and 464.33.

REMARKS. The main species present in Robin Hood's Bay is *C. laevigatus*, but a more compressed species with obsolete ribbing, eg. *C. fastigatus* Schindewolf (1961: 211, pl. 30, figs 8–10), may also be present amongst the small specimens determined as *Cymbites* sp. indet. in the Denotatus and Simpsoni Subzones.

## Superfamily EODEROCERATACEAE Spath, 1929

## Family EODEROCERATIDAE Spath, 1929

## Genus MICRODEROCERAS Hyatt, 1871

***Microderoceras scoresbyi*** (Simpson, 1843)

- 1843 *Ammonites scoresbyi* Simpson: 12.  
 1911 *Xipheroceras scoresbyi* (Simpson); Buckman: pls 39A, B (holotype, WM 173). C (topotype, GSM 23616), both probably from bed 441.2.

RANGE. One specimen found in bed 441.2, Birchi Subzone.

REMARKS. This single specimen differs from *M. birchi* in having higher and thicker whorls that are slightly less evolute.

***Microderoceras birchi*** (J. Sowerby, 1820) Pl. 5, fig. 7

- 1820 *Ammonites birchi* J. Sowerby: 121, pl. 267.  
 1961 *Microderoceras birchi* (J. Sowerby); Dean *et al.*: pl. 66, fig. 3 (BM 67973, from the Dorset coast).  
 1973 *Microderoceras birchi* (J. Sowerby); Donovan & Forsey: 10, pl. 1, fig. 1 (lectotype, BM 43923, from the Dorset coast).

RANGE. Found only in bed 433.3, Birchi Subzone; 5 specimens.

REMARKS. The five large specimens in bed 433.3 have typical very evolute whorls, with bituberculate ribs up to the end of the largest specimen at 235 mm diameter, and considerable variation in whorl thickness. The specimen figured in Pl. 5, fig. 7 appears to have a complete body-chamber nearly 1½ whorls long, ending in an (?adult) aperture at 210 mm diameter.

## Genus XIPHEROCERAS Buckman, 1911

***Xipheroceras dudressieri*** (d'Orbigny, 1845) Pl. 5, fig. 2

- 1845 *Ammonites dudressieri* d'Orbigny: 325, pl. 103, figs 1, 2.  
 1926b *Xipheroceras dudressieri* (d'Orbigny); Spath: 172, pl. 9, fig. 6 (BM C.2235a, a typical example from the Obtusum Subzone, Dorset).  
 1994 *Xipheroceras dudressieri* (d'Orbigny); Fischer: 91, pl. 19, fig. 3 (from Mulhausen, France).

RANGE. One specimen in bed 446.33, Obtusum Subzone.

***Xipheroceras ziphus*** (Zieten, 1830) Pl. 5, fig. 5

- 1830 *Ammonites ziphus* Zieten: 6, pl. 5, fig. 2 (holotype, BM 62590, from Heiningen, Württemberg, Germany).  
 1926 *Xipheroceras ziphus* (Zieten); Buckman: pl. 732 (GSM 47832, coarsely ribbed inner whorls, from the Obtusum Subzone, Dorset).  
 1928 *Xipheroceras revertens* Buckman: pls 772A, B (a typical large example of *X. ziphus* from the Obtusum Subzone, Dorset).

1973 *Xiphoceras planicosta* Buckman; Donovan & Forsey: 9, pl. 3, figs 1, 2 (GSM 25033, Obtusum Zone, Dorset).

RANGE. Beds 446.4–453.1, Obtusum and Stellare Subzones; 7 specimens.

REMARKS. In addition to those listed above, single examples of *Xiphoceras* sp. indet. occur in beds 446.32, 453.2 and 453.3.

Genus *BIFERICERAS* Buckman, 1913

*Bifericeras bifer* (Quenstedt, 1845)

1845 *Ammonites bifer* Quenstedt: Quenstedt: 83, pl. 4, fig. 14 (from Württemberg, Germany).

?1925a *Ophideroceras ziphoides* Spath: 138–40, figs 1, 2a, 2b (from low in the Oxynotum Subzone, Mill Beck Nab, Robin Hood's Bay; originally in Hull Museum, but now destroyed; see Donovan & Forsey, 1973: 16).

1957 *Bifericeras bifer* (Quenstedt); Söhl: 402, pl. 19, figs 1–7 (from Württemberg, Germany).

1976 *Bifericeras bifer* (Quenstedt); Schlegelmilch: 58, pl. 25, fig. 3 ('neotype', from Württemberg, Germany).

1990 *Bifericeras bifer* (Quenstedt); Hollingworth *et al.*: 165, pl. 2, figs 1–12 (BM C.93398–93409, from the Oxynotum Subzone, Somerset).

RANGE. Bed 483.1, Oxynotum Subzone; 5 specimens. The destroyed holotype of *Ophideroceras ziphoides* Spath might have been a large example of *Bifericeras bifer*.

*Bifericeras vitreum* (Simpson, 1855)

1855 *Ammonites vitreus* Simpson: 46.

1924 *Microceras vitreum* (Simpson); Buckman: pl. 529 (holotype, WM 462, possibly from bed 486.2).

1976 *Bifericeras vitreum* (Simpson); Schlegelmilch: 146, pl. 25, fig. 9 (WM 462).

RANGE. One specimen in bed 486.2, Oxynotum Subzone.

*Bifericeras donovani* Dommergues & Meister, 1992

Pl. 8, fig. 3

1992 *Bifericeras donovani* Dommergues & Meister: 223, figs 5(8)–5(10), figs 7(1), 7(2), 7(3) (holotype), 7(4)–7(11) (all from nodules in the lower part of bed 501.1 at Wine Haven).

RANGE. Occurs only in bed 501.1, base of Taylori Subzone; 18 specimens.

Genus *CRUCILOBICERAS* Buckman, 1920

*Cruciloboceras densinodulum* Buckman, 1923

Pl. 6, fig. 1

1876 *Aegoceras obsoletum* (Simpson); Blake: 276, pl. 7, fig. 1 (BM C.17939, from bed 486.3).

1923 *Cruciloboceras densinodulum* Buckman: pl. 442 (holotype, from Lyme Regis, Dorset).

1926b *Cruciloboceras ornatilobatum* Spath: 176, pl. 11, fig. 1 (holotype, from Lyme Regis, Dorset).

RANGE. Beds 486.3–488, Densinodulum and Raricostatoides Subzones; 19 specimens.

REMARKS. The well-preserved *C. densinodulum* in beds 486.3 (Pl. 6, fig. 1) are unituberculate (ie. have ventro-lateral but no prominent

umbilical-lateral tubercles), are moderately to finely ribbed on the inner whorls, and are characteristically much more compressed than *C. densinodulum* (Oppel). Small specimens or inner whorls of *C. densinodulum* are very similar to '*Bifericeras (Hemimicroceras) subplanicosta* (Oppel, 1856) and the relationship between the two (eg. a macroconch/microconch pair or size difference only) has yet to be resolved.

Genus *EODEROCERAS* Spath, 1925

*Eoderoceras armatum* (J. Sowerby, 1815)

Pl. 5, fig. 9; Pl. 8, fig. 2

1815 *Ammonites armatus* J. Sowerby: 215, pl. 95.

1843 *Ammonites anguiformis* Simpson: 17.

1843 *Ammonites owenensis* Simpson: 25.

1855 *Ammonites miles* Simpson: 65.

1880/82 *Aegoceras armatum* (J. Sowerby); Wright: 340 (1882), pl. 28 (1880), figs 1, 2 (SM J18222), 3–5 (SM J18223), both from beds 497–99; non pl. 29, =*Eoderoceras pugnax* (Buckman, 1914: 103c).

1911 *Deroceras miles* (Simpson); Buckman: pl. 44 (holotype, WM 162, from bed 498 or 499).

1912 *Deroceras anguiforme* (Simpson); Buckman: pl. 64 (holotype, WM 86, from beds 497–99).

1912 *Deroceras owenense* (Simpson); Buckman: pl. 65 (holotype, WM 476, from beds 497–99).

1926b *Deroceras eusculptum* Spath: 175, pl. 10, fig. 3 (BM C.26907, from Lyme Regis, Dorset).

1992 *Eoderoceras* gr. *miles* (Simpson); Dommergues & Meister: 231, figs 5(5), 5(7) (from bed 497).

2000 *Eoderoceras armatum* (J. Sowerby); Blau *et al.*: 269, figs 4 (1–7), 5 (1, 3, 5), 6 (1), 7, 8 (from NW Germany).

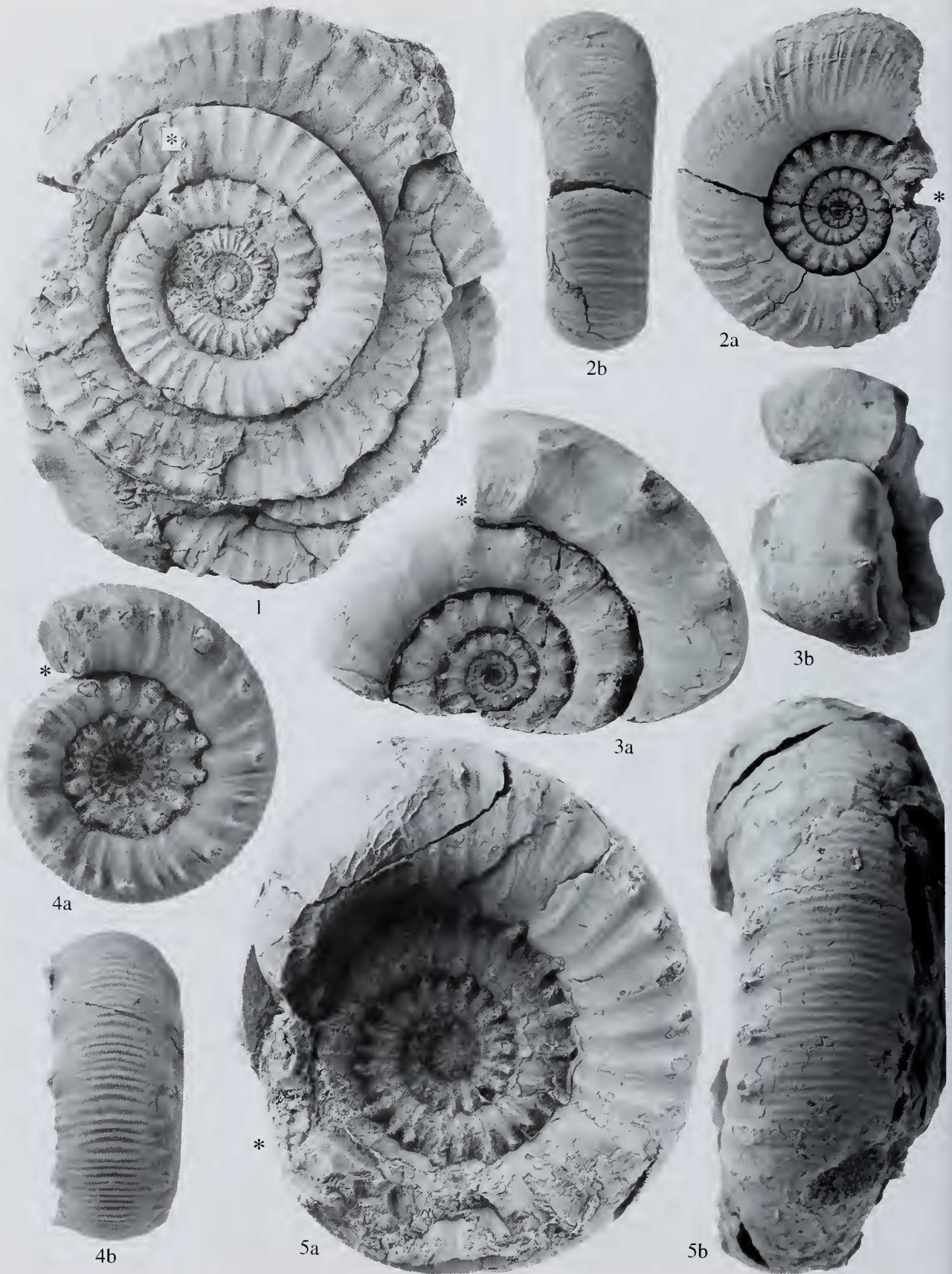
RANGE. Beds 494–499, Macdonnelli and Aplanatum Subzones; 62 specimens.

TYPE SPECIMEN. BM C.67323, Sowerby Collection, from Robin Hood's Bay, probably from bed 497, is here designated neotype.

MEASUREMENTS (in mm)

	D	Wh	Wb	U
BM C.67323	128.0	32.0 (0.25)	31.5 (0.25)	69.8 (0.54)
BM C.67323	102.0	27.4 (0.27)	–	53.3 (0.52)

REMARKS. Sowerby (1815: 215) stated that many examples of his species, including the specimen that he figured, which was collected by Mr. Strangeways, came from 'the great Alum-clay formation at Whitby' (a stratigraphical term that was used by Sowerby, Young & Bird, Sedgwick and others for beds that included ones as low as the Upper Sinemurian/Lower Pliensbachian clays). Sowerby did not mention any other locality in his original description, so it is not possible to agree with Spath's (1925a: 137, 167) statements that 'the true *D. armatum* apparently does not occur in Yorkshire', and 'Sowerby's type is not preserved in the BM . . . and has always seemed to me to be more like a Charmouth than a Whitby specimen', nor with Donovan's (1958: 32) opinion that 'Sowerby's type specimen . . . was almost certainly obtained from the Dorset coast'. It is not permissible to transfer the type locality to Dorset on the opinion that the Yorkshire specimens are morphologically different from those in Dorset, or the belief that the pyritic preservation and frequency of decay perceived from Sowerby's figure are more reminiscent of Dorset examples. The Yorkshire specimens are not morphologically different from those in Dorset (two especially fine



Yorkshire specimens had been figured by Wright, 1880: pl. 28), and there are many Yorkshire examples preserved in iron pyrites, especially in beds 497 and 499, which are also subject to decay, though less readily than the Dorset ones.

After Spath wrote about the species in 1925, the remaining ammonites in the Sowerbys' collections were obtained by The Natural History Museum in 1935, and amongst them is a medium to large example (BM C.67323) of *Eoderoceras armatum* from Robin Hood's Bay, which might even have been one of Sowerby's original syntypes. At 132 mm diameter it is slightly larger than Sowerby's figure of a 117 mm diameter specimen (assuming that his figure is natural size), but it does not differ in any morphological feature from that figure, and the part now missing at the beginning of the final whorl was once present, judging from remaining traces of old glue. There are some patches of pyritic preservation on the inner whorls, which fortunately do not appear to be subject to decay. As a possible original syntype, and a definite topotype, it is a close morphological match with Sowerby's figured specimen and is clearly the best neotype that can now be selected. It presents an unexpected opportunity to finally settle the identity of this frequently quoted species.

The neotype (Pl. 5, fig. 9) consists of 6–6½ septate whorls up to about 110 mm diameter, followed by a quarter of a whorl of body chamber ending at 132 mm diameter. The whorls are very evolute, the whorl section is near-circular and the umbilical wall and edge are evenly rounded. There are many fine indistinct radial ribs between stronger periodic lateral ribs that end in prominent ventro-lateral tubercles. Ribs of moderate strength cross the venter, curving gently forwards, and there are 3–5 such ribs between adjacent ventro-lateral tubercles. There are no umbilical tubercles.

In Robin Hood's Bay there are a few specimens in the Macdonnelli Subzone, then the species becomes much more common in the Aplanatum Subzone, with 44, 8 and 7 examples collected by Bairstow from beds 497, 498 and 499 respectively. The highest in bed 499 is 0.15 m below the top, and only 0.23 m below the top of the Sinemurian. Six specimens were found lower in bed 499 (0.15–0.37 m above the base), and the best preserved of them is figured in Pl. 8, fig. 2; the latter has a phragmocone ending at ca. 68 mm diameter at the position indicated on the figure, then it has a body-chamber 1.125 whorls long ending at a final aperture at ca. 125 mm diameter (the final 0.35 whorls are detached and poorly preserved, and are not figured). There is no overlap between *Eoderoceras* and *Apoderoceras*, and the lowest example of the latter genus occurs in bed 501.1 just 0.36 m above the highest *Eoderoceras*.

### *Eoderoceras hastatum* (Young & Bird, 1828) Pl. 6, fig. 3

- 1828 *Ammonites hastatus* Young & Bird: 261, pl. 14, fig. 3.  
 1914 *Deroceras hastatum* (Young & Bird); Buckman: pls 102A, B (?holotype, WM 661, from bed 493.2).  
 1914 *Deroceras impavidum* Buckman: pl. 104 (holotype, WM 166; probably from bed 493.2).

RANGE. Found only in bed 493.2, Raricostatoides Subzone; 4 specimens.

REMARKS. *E. hastatum* has more depressed whorls and more widely spaced ventro-lateral tubercles than *E. armatum* which occurs at higher levels. The specimen figured here (Pl. 6, fig. 3) is very like the holotype in having striate ribs angled strongly backwards from the umbilical edge, and the almost identical holotype of Buckman's species *impavidum* probably came from the same bed 493.2.

### Other species of *Eoderoceras*:

- ?*E. diversum* (Simpson, 1843: 13); Blake, 1876: 282, pl. 8, fig. 3 (SM J34799); Howarth, 1962: 107, pl. 15, fig. 9 (SM J34799, neotype).  
 The neotype represents a highly evolute, serpentine species, which might be an *Eoderoceras*, but no specimens were found by Bairstow.

### Genus *PROMICROCERAS* Spath, 1925

#### *Promicroceras planicosta* (J. Sowerby, 1814) Pl. 5, fig. 3

- 1814 *Ammonites planicosta* J. Sowerby: 167, pl. 73.  
 1822 *Ammonites aureus* Young & Bird: 248, pl. 13, fig. 6) (type specimen lost).  
 ?1843 *Ammonites siphuncularis* Simpson: 46.  
 ?1912 *Androgynoceras siphunculare* (Simpson); Buckman: pl. 48 (holotype, WM 485, from beds 451–454).  
 1925a *Promicroceras planicosta* (J. Sowerby); Spath: 299–302, fig. 8f.  
 1925a *Promicroceras aureum* (Young & Bird); Spath: 301, fig. 8d (BM 17160, possibly from 451).  
 1926b *Promicroceras planicosta* (J. Sowerby); Spath: 171, pl. 9, figs 1 (BM C.26337), 7 ('neotype', BM C.2235b); both from Charmouth, Dorset.

RANGE. Beds 446.33–454.1, Obtusum and Stellare Subzones; 290 specimens.

REMARKS. The current interpretation of *Promicroceras planicosta* may not be satisfactory. After lengthy discussion, Spath (1925a: 299–302) selected as neotype the specimen BM C.2235b (T. Wright Colln, 1887) from Charmouth, Dorset (almost certainly from bed 85), even though Sowerby (1814: 167) said that his main specimens came from Marston Magna, and it is highly probable that the original block of specimens that he figured (Sowerby, 1814: pl. 73, now lost) came from the Marston Marble at Marston Magna, Somerset. Spath (1925a: 305) then created a new species, *P. marstonense*, for the form at Marston Magna, using as holotype a specimen (BM 43914b) from Sowerby's syntypes of *P. planicosta*. The selection of a Charmouth specimen as neotype of *P. planicosta* was unfortunate, and may be invalid because there were Marston Magna specimens available amongst the original syntypes. The designation of a Marston Magna specimen as neotype (or lectotype) would have been much more in accordance with Sowerby's original concept of his species. In any case, the forms of *Promicroceras* at Charmouth and Marston Magna appear to be very close and the two names are probably

### PLATE 6

Fig. 1 *Cruciloboceras densinodulum* Buckman. Bed 486.3, CA 3828; the body chamber is exactly one whorl long.

Fig. 2 *Apoderoceras aculeatum* (Simpson). Bed 526.5, CA 4031.

Fig. 3 *Eoderoceras hastatum* (Young & Bird). Bed 493.2, CA 3895, × 0.6; suture-lines that probably mark the end of the phragmocone are visible exactly one whorl before the aperture.

Figs 4, 5 *Apoderoceras subtriangulare* (Young & Bird). 4, bed 520.7, CA 4018; probably a complete adult microconch, with a body chamber exactly one whorl long and a slightly contracted final aperture. 5, bed 502, CA3990; the asterisk marks the probable end of the phragmocone.

All figures natural size, except Fig. 3.

synonyms. Two other names that are probably also synonyms of *P. planicosta* are *P. perplanicosta* (Spath, 1925a: 269; 1926b, 172, pl. 9, fig. 2) and *P. precompressum* Spath (1926b, 173, pl. 9, fig. 5), both from beds 83 or 85 at Charmouth.

*Promicroceras capricornoides* (Quenstedt, 1883)

1883 *Ammonites capricornoides* Quenstedt: 129, pl. 17, fig. 11 (from Württemberg, Germany).

1926b *Promicroceras capricornoides* (Quenstedt): Spath: 172, pl. 9, fig. 3 (from the Turneri Zone, Charmouth, Dorset).

RANGE. Beds 436–446.32, Birchi and basal Obtusum Subzones; 39 specimens.

REMARKS. *P. capricornoides* is slightly more involute, has a more rapidly increasing whorl height and slightly fewer ribs than *P. planicosta*.

Family COELO CERATIDAE Haug, 1910

Genus APODEROCERAS Buckman, 1921

REMARKS. Identification of the horizons from which the Yorkshire type and figured specimens were obtained is especially uncertain in *Apoderoceras*. The originals of *A. subtriangulare* and its two synonyms (*A. hamiltoni* and *A. spicatum*) could have come from any of beds 502, 504–07 509, 520 and 522, all of which contain many large fragments of outer whorls as well as a few more complete specimens like the original of *A. 'hamiltoni'*. Similarly, the originals of *A. aculeatum* and its three synonyms (*A. decussatum*, *A. mutatum* and *A. leckenbyi*) could have come from any of beds 523–526.

*Apoderoceras subtriangulare* (Young & Bird, 1822)

Pl. 5, fig. 8; Pl. 6, figs 4, 5

1822 *Ammonites subtriangularis* Young & Bird: 250, pl. 12, fig. 4.

1843 *Ammonites hamiltoni* Simpson: 27.

1843 *Ammonites spicatus* Simpson: 28.

1913 *Deroceras subtriangulare* (Young & Bird); Buckman: pl. 71 (holotype, WM 927).

1914 *Deroceras spicatum* (Simpson); Buckman: pl. 103 (holotype, WM 920).

1924 *Apoderoceras hamiltoni* (Simpson); Buckman: pls 530A, B (both are the holotype, WM 165).

1992 *Apoderoceras* sp. indet.: Dommergues & Meister: 232, fig. 5(6) (from nodules at the middle of bed 501.1, Wine Haven).

RANGE. Beds 501.1–522.1, Taylori Subzone; 41 specimens.

REMARKS. The lowest examples of *Apoderoceras* are three specimens in bed 501.1. Two are very small cadicones, one large enough to have ventro-lateral tubercles, while the third (Pl. 5, fig. 8) is part of one side of a whorl at a whorl height of 35 mm that has obscure radial ribs and striae and pointed ventro-lateral tubercles. It is identical with *A. subtriangulare* at a similar size, and is important for fixing the base of the Taylori Subzone at this level.

Large *A. subtriangulare* up to 350 mm diameter, with large ventro-lateral spines and broad flat venters occur in bed 502 and at many more horizons up to bed 522.1. Most are fragments of outer whorls with nothing to link them to the few inner whorls, but an example in bed 507.1 (CA 4006) has both inner and outer whorls, and proves that small inner whorls like those in Pl. 6, fig. 5 and the very well-preserved specimen of Pl. 6, fig. 4 develop into the massive outer whorls with broad flat venters and very large ventro-lateral

spines that are characteristic of *A. subtriangulare*. The holotype of *A. subtriangulare* (Buckman, 1913: pl. 71) is a fragment of such a large outer whorl. Of the two Simpson species that are placed in synonymy, the holotype of *A. spicatum* (Buckman, 1914: pl. 103) is a very similar fragment of a large outer whorl, though the broad flat venter is not shown because only one side is preserved, while the holotype of *A. hamiltoni* (Buckman, 1924: pl. 530) is one of the few specimens that show inner and outer whorls preserved in the same individual. [Note the remarkable resemblance of Pl. 6, fig. 4 to a depressed-whorled species of the Toarcian genus *Peronoceras*, eg. *P. perarmatum* (Young & Bird), Howarth, 1978: pl. 4, fig. 7; the latter differs only in having well-defined ribs on the side of the whorl, compared with the poor, irregular or striate ribs on the inner whorls of *Apoderoceras subtriangulare*].

*Apoderoceras aculeatum* (Simpson, 1843)

Pl. 6, fig. 2; Pl. 7, fig. 1

?1843 *Ammonites marshallani* Simpson: 24.

1843 *Ammonites decussatus* Simpson: 25.

1843 *Ammonites aculeatus* Simpson: 27.

1855 *Ammonites mutatus* Simpson: 63.

1876 *Aegoceras aculeatum* (Simpson); Blake: 278, pl. 7, fig. 4 (BM C.17878).

1880/82 *Aegoceras leckenbyi* Wright: 344 (1882), pl. 30 (1880), figs 1–3 (lectotype of *leckenbyi* (designated Howarth, 1962: 109), SM J18224), figs 4–7 (paralectotype of *leckenbyi*, also holotype of *decussatum*, SM J18225).

1913 *Deroceras aculeatum* (Simpson); Buckman: pls 72A–C (paratype, WM 177; the holotype is lost).

1914 *Deroceras mutatum* (Simpson); Buckman: pl. 105 (holotype, GSM 26406).

1962 *Apoderoceras decussatum* (Simpson); Howarth: 109, pl. 16, fig 1 (holotype, SM J18225).

?1962 *Apoderoceras marshallani* (Simpson); Howarth: 109, pl. 15, fig. 5 (holotype, WM 468); the holotype is only 16 mm diameter, and although it could be a very small example of *A. aculeatum*, Simpson's species is not accurately determinable.

RANGE. Beds 523–526.6, Taylori Subzone; 15 specimens. There are also single specimens of *Apoderoceras* sp. indet. in beds 526.7 and 529.

REMARKS. Specimens from beds 523–526 differ from *A. subtriangulare* in beds 501–522 in having the outer whorls more rounded, with evenly arched whorl sides and venter, no definite ventro-lateral angle, and smaller ventro-lateral tubercles on the inner whorls. These stratigraphically higher specimens belong to the species *A. aculeatum* (Simpson), of *A. decussatum* and *A. leckenbyi* are synonyms (*Ammonites aculeatum* and *A. decussatum* are both of Simpson, 1843, and therefore have equal priority; the name for the species was selected by Blake (1876: 278), who, as 'First Reviser' (ICZN Code, art. 24.2), chose *aculeatum* as the name for the species). *A. marshallani*, another Simpson name of the same date (1843), is probably also a synonym, but the holotype is too small to be definitely identifiable, and *A. mutatum* (Simpson, 1855) and *A. leckenbyi* (Wright, 1880) are two more synonyms, judging from their well-preserved type specimens.

The specimen figured in Pl. 7, fig. 1 is a fairly large, wholly septate example of *A. aculeatum* and Pl. 6, fig. 2 has well-preserved inner whorls showing much smaller ventro-lateral tubercles than in *A. subtriangulare* (cf. inner whorls of Pl. 6, fig. 5).

Other species of *Apoderoceras*:

1. ?*Apoderoceras sinuatum* (Simpson, 1855: 62); Buckman, 1914:



pl. 94 (holotype, WM 160). No specimens resembling this holotype were found by Bairstow.

2. ?*A. armiger* (Simpson, 1855: 66 (*non Ammonites armiger* J. de C. Sowerby, 1840)); Howarth, 1962: 107. From Simpson's description this was probably an *Apoderoceras*, but the type specimen is lost and the species is not identifiable.

#### Genus *HYPERDEROCERAS* Spath, 1926

REMARKS. Bairstow found only one poorly preserved example (CA 4053) of *Hyperderoceras* sp. indet. in bed 540.1 (Polymorphus Subzone). This shows parts of inner whorls at 15–50 mm diameter that have strong ribs and ventro-lateral tubercles, followed by septate fragments of larger whorls with a quadrate whorl section, where both whorl height and breadth are 50–60 mm, i.e. they are not compressed like *Epideroceras* at this size. Any of the following four Simpson species might have come from this horizon, but the Bairstow specimen is not specifically identifiable:

1. *Hyperderoceras mamillatum* (Simpson, 1843: 28 (*non Ammonites mamillatus* Schlotheim, 1813)); Howarth, 1962: 108, pl. 15, fig. 6 (neotype (designated by Howarth, 1962: 108), WM 2102).
2. *H. validum* (Simpson, 1855: 39); Blake, 1876: 278, pl. 7, fig. 3 (SM – ?holotype); Buckman, 1913: pl. 83 (holotype, SM J3275).
3. *H. retusum* (Simpson, 1855: 62); Buckman, 1913: pl. 82 (holotype, WM 184).
4. *H. nativum* (Simpson, 1855: 68); Buckman, 1913: pl. 84 (holotype, WM 931).

#### Family *PHRICODOCERATIDAE* Spath, 1938

##### Genus *PHRICODOCERAS* Hyatt, 1900

REMARKS. Species of *Phricodoceras* show a considerable amount of variation in rib-density, in the development of lateral tubercles, and in overall size of the tubercles. The specimens from Robin Hood's Bay suggest that a sparsely-ribbed species, here identified as *P. taylori*, occurs in the lower half of the Taylori Subzone, while a more densely-ribbed species, *P. cornutum*, occurs in the upper half of the subzone. Tubercle strength depends to some extent on preservation, and in any species tubercles are more prominent when the shell is preserved, compared with their appearance on internal moulds. The Robin Hood's Bay specimens are identified below mainly according to their rib-density, but tubercles are accorded some significance when they are especially large.

#### *Phricodoceras taylori* (J. de C. Sowerby, 1826)

- 1826 *Ammonites taylori* J. de C. Sowerby: 23, pl. 514, fig. 1 (holotype, lost (originally in Norwich Museum), from Glacial Drift. Happisburgh, north Norfolk, perhaps derived from the Yorkshire coast).
- 1855 *Ammonites quadricornutus* Simpson: 71.
- 1884 *Ammonites quadricornutus* Simpson: 106.
- 1911 *Phricodoceras quadricornutum* (Simpson); Buckman: pl. 33 (holotype, WM 495; possibly from beds 501–517, lower than *P. cornutum*).

RANGE: Beds 501.3–524.1, Taylori Subzone; 8 specimens.

REMARKS. *P. taylori* occurs in the lower and middle parts of the Taylori Subzone at Robin Hood's Bay, where the poorly preserved specimens have the widely spaced ribs (12–13 per whorl at 50 mm diameter) that are typical of the species. The holotype of *Ammonites quadricornutus* has the same rib-density, and the strength of the

tubercles is similar to that shown in Sowerby's figure of *taylori*, even after allowances are made for slightly different modes of preservation.

#### *Phricodoceras cornutum* (Simpson, 1843) Pl. 7, fig. 2

- 1843 *Ammonites cornutus* Simpson: 31.
- 1855 *Ammonites cornutus* Simpson: 71.
- 1884 *Ammonites taylori* J. de C. Sowerby; Simpson: 105 (including *Ammonites cornutus* which Simpson now considered to be a synonym).
- 1911 *Phricodoceras cornutum* (Simpson); Buckman: pl. 32 (holotype, WM 185).
- 1976 *Phricodoceras cornutum* (Simpson); Schlegelmilch: 152, pl. 28, fig. 1 (WM 185).

RANGE: Beds 524.3–530.2, Taylori Subzone; 8 specimens.

REMARKS. *P. cornutum* occurs higher in the Taylori Subzone than *P. taylori*, and differs from the latter in having more ribs (17–20 per whorl at 50 mm diameter) and smaller tubercles.

#### *Phricodoceras nodosum* (Quenstedt, 1846)

- 1846 *Ammonites taylori nodosus* Quenstedt: 136, pl. 9, fig. 21 (holotype, from Württemberg, Germany) (*non Ammonites nodosus*, Bruguière, 1789).
- 1961 *Phricodoceras* aff. *taylori* (J. de C. Sowerby); Dean *et al.*: pl. 68, fig. 5 (BM C.17981, probably from bed 520).
- 1980 *Phricodoceras nodosum* (Quenstedt); Schlatter: 78, pl. 6, figs 5, 6 (from Württemberg, Germany).

RANGE. A single specimen in bed 520.5, Taylori Subzone.

REMARKS. All the specimens listed above have the same rib-density as *P. taylori*, but they have much more prominent tubercles. Even on the internal mould the tubercles appear to be genuinely much larger, as can be seen on the specimen figured by Dean *et al.* (1961), which has both shell and internal mould preserved on different portions of the shell.

#### Genus *EPIDERO CERAS* Spath, 1923

REMARKS. The only examples of *Epideroceras* found by Bairstow were parts of two specimens in bed 542.4, Polymorphus Subzone. They are fragments of large septate whorls, with compressed whorl sections at 45–60 mm whorl height, a rounded venter, and radial ribs, but no tubercles. They are too fragmentary and poorly preserved to be specifically identified. The following Simpson species might have come from bed 542.4:

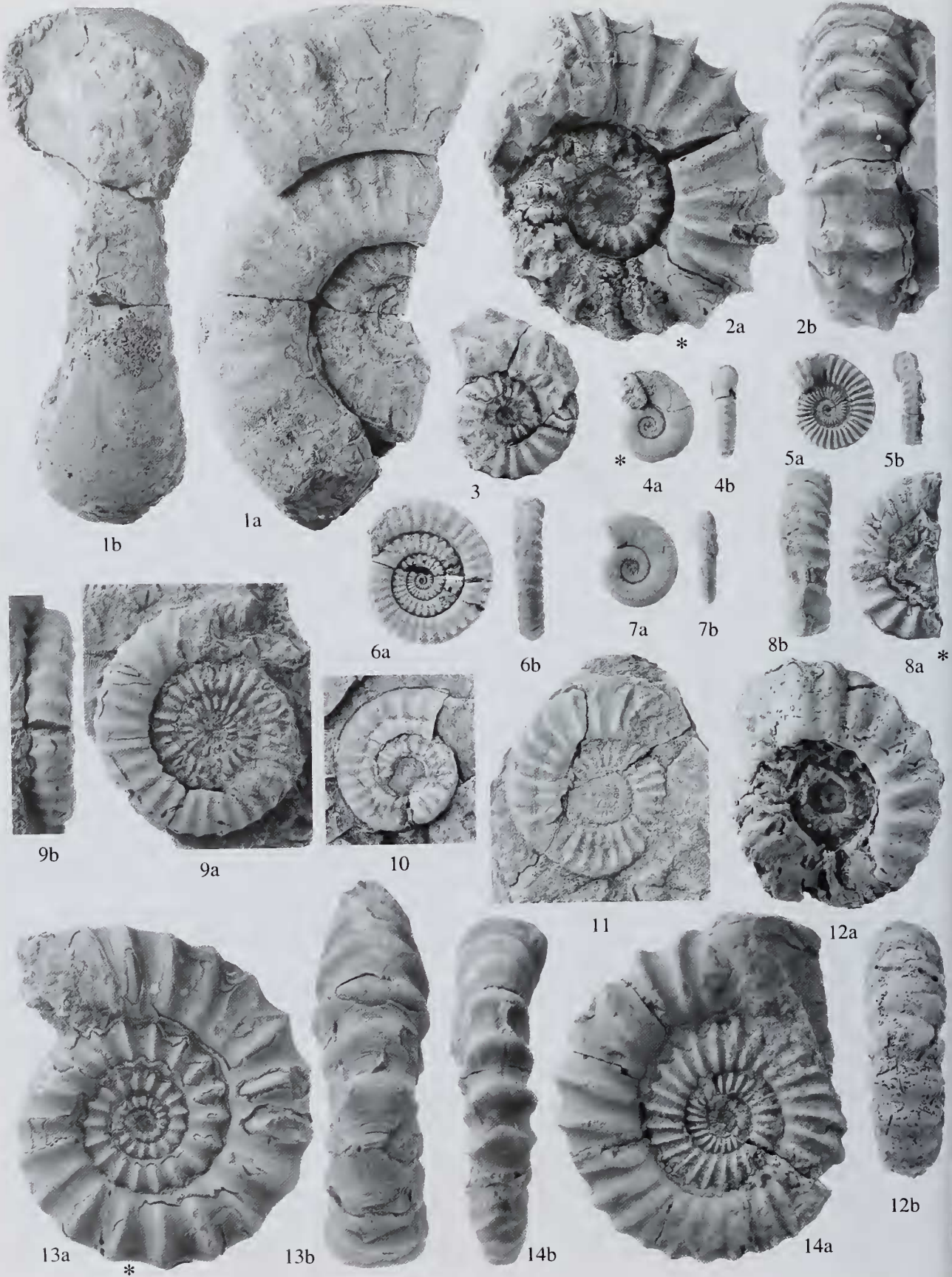
*Epideroceras sociale* (Simpson, 1855: 39); Blake, 1876: 278, pl. 7, fig. 6 (SM collection); Buckman, 1914: pl. 95 (holotype, WM 68).

#### Family *POLYMORPHITIDAE* Haug, 1887

##### Genus *GEMMELLAROCERAS* Hyatt, 1900

SYNONYMS. *Tubellites* Buckman, 1924; *Leptonotoceras* Spath, 1925.

REMARKS. *Gemmellaroceras* has been divided in two subgenera: *Gemmellaroceras* s.s., in the Jamesoni Zone and younger beds, in which the first lateral lobe is trifid, and an earlier Raricostatum to basal Jamesoni Zone subgenus *G.* (*Leptonotoceras*), in which the first lateral lobes are bifid (Dubar & Mouterde, 1961: 237; Geczy, 1976: 73–75). In Robin Hood's Bay *Gemmellaroceras* ranges from the top part of the Macdonnelli Subzone up to near the top of the Taylori Subzone. Most specimens belong to the very small species *G. tubellum* (Simpson) (the type species of *Tubellites* Buckman, 1924), and those specimens that



are large enough to have divided first lateral lobes appear to have the bifid lobes of *Leptonotoceras*. However, many of the specimens are very small and the largest (in bed 501.2) is only 19 mm diameter. In the top part of the Taylori Subzone at Robin Hood's Bay the much larger species *Gemmellaroceras rutilans* has the trifid first lateral lobes of *Gemmellaroceras* s.s. Whether this division into subgenera is real, or is a function of the size to which species grow and therefore the complexity attained by their suture-lines, has still to be resolved.

### *Gemmellaroceras tubellum* (Simpson, 1855)

- 1855 *Ammonites tubellus* Simpson: 42.  
 1876 *Aegoceras tubellum* (Simpson); Blake: 279, pl. 5, fig. 7.  
 1924 *Tubellites tubellus* (Simpson); Buckman: pl. 491 (holotype, WM 981; ?probably from bed 497 or 498).

RANGE. Beds 495.7–505.1, Macdonnelli to Taylori Subzones; 104 specimens.

REMARKS. After its first appearance in the top bed of the Macdonnelli Subzone, *G. tubellum* becomes much more common in the Aplanatum and bottom of the Taylori Subzones.

### *Gemmellaroceras rutilans* (Simpson, 1843) Pl. 7, fig. 4

- 1843 *Ammonites rutilans* Simpson: 45.  
 1962 *Polymorphites rutilans* (Simpson); Howarth: 110, pl. 15, figs 7 (neotype (designated Howarth, 1962: 110), WM 95), 8 (WM 94); both probably from bed 526.1 or 530.1.

RANGE. Beds 526.1 and 530.1. Taylori Subzone; 4 specimens.

REMARKS. *G. peregrinum* (Haug, 1887: 114, pl. 4, fig. 5) is a very similar (or identical) species that occurs in the upper part of the Taylori Subzone in Dorset (bed 108), where specimens attain large sizes of up to 90 mm diameter.

## Genus *POLYMORPHITES* Haug, 1887

### *Polymorphites caprarius* (Quenstedt, 1856) Pl. 7, fig. 9

- 1856 *Ammonites caprarius* Quenstedt: 131, pl. 16, fig. 1 (holotype, from Balingen, Württemberg, Germany; BM C.55358 is a cast of this specimen).  
 1885 *Ammonites caprarius* Quenstedt: Quenstedt: 244, pl. 30, figs 40, 41 (holotype refigured).  
 1976 *Platypleuroceras caprarium* (Quenstedt); Schlegelmilch: 63, pl. 29, fig. 5 (holotype refigured).  
 1980 *Polymorphites caprarius* (Quenstedt); Schlatter: 92.

RANGE. Beds 538–542.5, Polymorphus Subzone; 87 specimens.

REMARKS. There seems to be no doubt that Quenstedt's figure of 1885 (pl. 30, fig. 41) is a drawing of the same specimen that he figured in 1856 (pl. 16, fig. 1). This specimen (Geological Institute, Tübingen University, Ce 5/30/41) was figured again by Schlegelmilch (1976); it is the holotype. Schlegelmilch's (1976: 63) designation of this specimen as neotype was not necessary. One of Baird's better preserved specimens from bed 539 is figured in Pl. 7, fig. 9.

### *Polymorphites trivialis* (Simpson, 1843) Pl. 7, fig. 7

- 1843 *Ammonites trivialis* Simpson: 10.  
 1876 *Amaltheus trivialis* (Simpson); Blake: 292, pl. 5, figs 6a (BM C.17891), 6b–d.  
 1912 *Polymorphites trivialis* (Simpson); Buckman: pl. 53, figs 1, 1a, 1b (the lectotype, WM 105, now lost), figs 2, 3 (paralectotypes).

RANGE. Beds 542.4–546.3, Polymorphus and Brevispina Subzones; 84 specimens.

REMARKS. Many examples of *P. trivialis* are found in beds 544.35–544.9 at the top of the Polymorphus and bottom of the Brevispina Subzones, and it is highly probable that the type specimens came from 544.35, 544.4, 544.5 or 544.9.

### *Polymorphites bronni* (Roemer, 1836) Pl. 7, fig. 5

- 1836 *Ammonites bronni* Roemer: 181, pl. 12, fig. 8 (holotype, from north Germany).  
 1884 *Ammonites bronni* Roemer; Quenstedt: 245, pl. 30, figs 44, 46, 48 (from Württemberg, Germany).  
 1976 *Polymorphites bronni* (Quenstedt); Schlegelmilch: 62, pl. 28, fig. 8 (original of Quenstedt, 1885: pl. 30, fig. 48).  
 1980 *Polymorphites bronni* (Quenstedt); Schlatter: 82, pl. 7, fig. 1, pl. 11, fig. 5 (from Württemberg, Germany).

RANGE. Beds 554–560.3, Jamesoni Subzone; 36 specimens.

REMARKS. Occurs in the upper half of the Jamesoni Subzone, and it differs from *P. trivialis* and *P. polymorphus* in having consistently stronger ribbing, small ventro-lateral tubercles and a mid-ventral keel. The Robin Hood's Bay specimens have been identified from Schlatter's (1980: 82) interpretation of the species.

### *Polymorphites polymorphus* (Quenstedt, 1845) Pl. 7, fig. 3

- 1845 *Ammonites polymorphus quadratus* Quenstedt: 87, pl. 4, fig. 9 (lectotype, from Germany, designated by Donovan & Forsey, 1973: 12).  
 1961 *Polymorphites polymorphus* (Quenstedt); Dean *et al.*: pl. 68, fig. 4 (from Gloucestershire).

## PLATE 7

- Fig. 1 *Apoderoceras aculeatum* (Simpson). Bed 524.3, CA 4022, × 0.5; wholly septate up to the aperture at ca. 210 mm diameter.  
 Fig. 2 *Phricodoceras cornutum* (Simpson). Bed 525, CA 4070.  
 Fig. 3 *Polymorphites polymorphus* (Quenstedt). Bed 555, CA 4317.  
 Fig. 4 *Gemmellaroceras rutilans* (Simpson). Bed 526.1, CA 4178; approximated adult septa occur at the position marked three-quarters of a whorl before the aperture.  
 Fig. 5 *Polymorphites bronni* (Roemer). Bed 560.3 (below the top 0.08 m), CA 4226; wholly septate.  
 Fig. 6 *Platypleuroceras aureum* (Simpson). Bed 546.2, CA 4480; the body chamber appears to be exactly one whorl long.  
 Fig. 7 *Polymorphites trivialis* (Simpson). Bed 544.35, CA 4326; wholly septate.  
 Fig. 8 *Aegoceras* (*A.*) *maculatum* (Young & Bird) var. *atavum* Spath. Bed 583.2, C.38874.  
 Fig. 9 *Polymorphites caprarius* (Quenstedt). Bed 539, CA 4237; a complete microconch, with a body chamber about two-thirds of a whorl long.  
 Figs 10, 11 *Tropidoceras futtereri* Spath. 10, bed 560.3 (in the top 0.08 m), CA 4544. 11, bed 568, CA 4545.  
 Figs 12, 13 *Aegoceras* (*A.*) *maculatum* (Young & Bird). 12, bed 581, C.41307. 13, bed 590.61, C. 38883.  
 Fig. 14 *Aegoceras* (*Oistoceras*) *sinuosiforme* Spath. Bed 598.1, C.38930.  
 All figures natural size, except Fig. 1.

1973 *Polymorphites polymorphus* (Quenstedt); Donovan & Forsey: 11, 12.

1980 *Polymorphites polymorphus* (Quenstedt); Schlatter: 84, pl. 7, fig. 2 (from Württemberg, Germany).

RANGE. Found only in bed 555, Jamesoni Subzone; 2 specimens.

REMARKS. Although the lectotype of *P. polymorphus*, as validly designated by Donovan & Forsey (1973: 12), is probably lost, Schlegelmilch's (1976: 61) designation of a 'neotype' is not valid because it is radically different in morphology from the lost lectotype. That specimen (Schlegelmilch, 1976: pl. 28, fig. 3) is the original of Quenstedt, 1885, pl. 30, fig. 9, and represents a round-whorled, striate species of *Polymorphites*, which was described as *P. lineatus* (Quenstedt, 1845) by Schlatter (1980: 86).

The relationship between *P. trivialis* (Simpson, 1843) and *P. polymorphus* (Quenstedt, 1845) remains to be clarified: both have wide ranges of morphological variation, and they may be synonyms. *P. trivialis* is abundant in the lower half of the Brevispina Subzone, but two examples of *P. polymorphus* (Pl. 7, fig. 3) that are identical with the specimen figured by Dean *et al.* (1961: pl. 68, fig. 4) and Schlatter (1980: pl. 7, fig. 2) were found in bed 555 in the Jamesoni Subzone. They have broad whorls, widely spaced ribs and ventro-lateral tubercles that are characteristic of the most strongly ornamented forms of both species.

#### Genus *PLATYPLEUROCERAS* Hyatt, 1867

##### *Platypleuroceras brevispina* (J. de C. Sowerby, 1827)

1827 *Ammonites brevispina* J. de C. Sowerby: 106, pl. 556, fig. 1.

1843 *Ammonites ripleyi* Simpson: 11.

1880/82 *Aegoceras brevispina* (J. de C. Sowerby); Wright: 361 (1882), pl. 32, fig. 2, 3 (1880) (holotype, BM 43915, from Pabba, Inner Hebrides, Scotland).

1909 *Uptonia ripleyi* (Simpson); Buckman: pl. 2 (holotype, WM 106, probably from beds 544.7–546.4).

1961 *Platypleuroceras brevispina* (J. de C. Sowerby); Dean *et al.*: pl. 69, fig. 1 (holotype).

RANGE. From beds 544.6–550, Brevispina and Jamesoni Subzones; 83 specimens.

##### *Platypleuroceras obsoleta* (Simpson, 1843)

1843 *Ammonites obsoletus* Simpson: 23.

1882 *Aegoceras brevispina* (J. de C. Sowerby); Wright: 361, pl. 50, figs 13, 14 (BM C.3126).

1914 *Uptonia obsoleta* (Simpson); Buckman: pl. 92 (holotype, WM 157).

RANGE. A single specimen in bed 544.7, Brevispina Subzone.

REMARKS. This is a single poorly preserved specimen with many ribs and ventro-lateral tubercles which is not good enough to elucidate the horizon of Simpson's larger and better preserved holotype.

##### *Platypleuroceras aureum* (Simpson, 1855) Pl. 7, fig. 6

1855 *Ammonites aureus* Simpson: 44 (*non Ammonites aureus* Young & Bird, 1822).

?1855 *Ammonites tenuispina* Simpson: 69 (the holotype is lost – see Howarth, 1962: 111).

1909 *Platypleuroceras aureum* (Simpson); Buckman: pl. 3 (holotype, WM 107, from bed 546.2 or 546.5).

RANGE. Beds 546.1–546.5, Brevispina Subzone; 23 specimens.

REMARKS. *P. aureum* is a more evolute species than *P. brevispina*, and is bituberculate (ie. both umbilical and ventro-lateral tubercles are well developed). A small, typical specimen is figured in Pl. 7, fig. 6.

#### Genus *UPTONIA* Buckman, 1897

##### *Uptonia jamesoni* (J. de C. Sowerby, 1827)

1827 *Ammonites jamesoni* J. de C. Sowerby: 105, pl. 555, fig. 1.

?1855 *Ammonites ignotus* Simpson, 1855: 61.

?1910 *Uptonia ignota* (Simpson); Buckman: pl. 21 (holotype, WM 159).

1973 *Uptonia jamesoni* (J. de C. Sowerby); Donovan & Forsey: 12, pl. 4, fig. 3 (neotype, BM C.40426, designated by Donovan & Forsey, 1973: 12, from Pabba, Inner Hebrides, Scotland).

RANGE. Beds 550–560.3, Jamesoni Subzone; 23 specimens.

REMARKS. Many of the 23 specimens in the Jamesoni Subzone are typical examples of the species, but they are mostly fragmentary, and none are preserved well enough to be figured.

##### *Uptonia lata* (Quenstedt, 1845)

1845 *Ammonites jamesoni* J. de Sowerby, var. *latus* Quenstedt: 88, pl. 4, fig. 1 (holotype, from Württemberg, Germany).

1980 *Uptonia lata* (Quenstedt); Schlatter: 113, pl. 12, figs 3, 4 (from Württemberg, Germany).

RANGE. Beds 558 and 560.3, Jamesoni Subzone; 6 specimens.

REMARKS. A more involute species than *U. jamesoni*, with much finer ribbing; identified according to Schlatter's (1980: 113) interpretation of Quenstedt's species.

#### Genus *TROPIDOCERAS* Hyatt, 1867

##### *Tropidoceras futtereri* Spath, 1923 Pl. 7, figs 10, 11

1923a *Tropidoceras futtereri* Spath: 8.

1928 *Tropidoceras futtereri* Spath; Spath: 228, pl. 16, fig. 8 (holotype, BM C.23687, from bed 118b, Charmouth, Dorset).

RANGE. Single specimens in beds 560.3 (top) and 568 (base), Masseanum Subzone.

##### *Tropidoceras masseanum* (d'Orbigny), var. *rotundum* (Futterer, 1893)

1893 *Cycloceras masseanum* (d'Orbigny), var. *rotundum* Futterer: 330, pl. 12, figs 3, 4 (holotype, from Württemberg, Germany).

1980 *Tropidoceras masseanum* (d'Orbigny) *rotundum* (Futterer); Schlatter: 138, pl. 19, fig. 4, pl. 20, figs 1, 2 (from Württemberg, Germany).

RANGE. Found only at the boundary of beds 567 and 568, Masseanum Subzone; 11 specimens.

#### Genus *PARINODICERAS* Trueman, 1918

REMARKS. Although considered by Spath (1938: 81) to be a subgenus of *Liparoceras*, *Parinodiceras* (including its synonym *Platynoticeras*) is now thought to have been derived from *Polymorphites* and is therefore placed in the family Polymorphitidae (Donovan, 1981: 111, 138).

***Parinodicer*** *parinodum* (Quenstedt, 1884)

- 1884 *Ammonites striatus parinodum* Quenstedt: 225, pl. 28, fig. 16.  
 1938 *Liparoceras (Parinodicer) parinodum* (Quenstedt); Spath: 82, pl. 6, fig. 5 (from Radstock, Somerset), pl. 25, figs 1, 4, 5 (all from Württemberg, Germany).  
 1976 *Liparoceras (Parinodicer) parinodum* (Quenstedt); Schlegelmilch: 67, pl. 32, fig. 3 (lectotype, from Oftringen, Württemberg, Germany).

RANGE. Beds 546.3, 548 and 554, Brevispina and Jamesoni Subzones; 3 specimens.

Family **LIPAROCERATIDAE** Hyatt, 1867

Genus **LIPAROCERAS** Hyatt, 1867

Subgenus **LIPAROCERAS** Hyatt, 1867

***Liparoceras (L.) cheltiense*** (Murchison, 1834)

- 1834 *Ammonites cheltiensis* Murchison: 20, fig. 1.  
 1904 *Liparoceras cheltiense* (Murchison); Buckman: pls 67, 67a (holotype, BM 74955a, from Gloucestershire).  
 1938 *Liparoceras cheltiense* (Murchison); Spath: 46.

RANGE. Two specimens in bed 562, Masseanum Subzone.

***Liparoceras (L.) heptangulare*** (Young & Bird, 1828)

- 1828 *Ammonites heptangularis* Young & Bird: 263, pl. 14, fig. 1.  
 1914 *Liparoceras heptangulare* (Young & Bird); Buckman: pls 108A–C (holotype, WM 170, probably from bed 575).  
 1938 *Liparoceras heptangulare* (Young & Bird); Spath: 59, pl. 7, fig. 1 (BM C.2685, possibly from bed 575).

RANGE. Single specimens in beds 571, 575 and 577, Valdani Subzone; the best preserved is in bed 577.

***Liparoceras (L.) cf. nptonense*** Spath, 1938

- 1938 *Liparoceras nptonense* Spath: 63, pl. 6, fig. 1, pl. 9, fig. 7, pl. 10, fig. 6 (holotype, BMC.12638, from Napton, Warwickshire), pl. 14, fig. 6, pl. 16, fig. 10 (all from Warwickshire or Leicestershire).

RANGE. Single specimens in beds 580 and 582.3, Luridum and Maculatum subzones.

***Liparoceras (L.) divaricosta*** (Trueman, 1919) Pl. 8, fig. 1

- 1919 *Androgynoceras divaricosta* Trueman: 278, pl. 22, fig. 1 (holotype, BM C.38326, from Lincolnshire).  
 1938 *Liparoceras divaricosta* (Trueman); Spath: 68, pl. 5, fig. 1 (holotype).

RANGE. A single specimen in bed 596.3, Figulinum Subzone.

Genus **AEGOCERAS** Waagen, 1869

Subgenus **AEGOCERAS** Waagen, 1869

***Aegoceras (A.) maculatum*** (Young & Bird, 1822)

Pl. 7, figs 12, 13

- 1822 *Ammonites maculatus* Young & Bird: 248, pl. 14, fig. 12.  
 1828 *Ammonites maculatus* Young & Bird; Young & Bird: 259, pl. 14, fig. 9.

- 1829 *Ammonites arcigerens* Phillips: 163, pl. 13, fig. 9.  
 1835 *Ammonites arcigerens* Phillips; Phillips: 135, pl. 13, fig. 9.  
 1875 *Ammonites arcigerens* Phillips; Phillips: 270, pl. 13, fig. 9.  
 1880/82 *Aegoceras maculatum* (Young & Bird); Wright: 368 (1882), pl. 34 (1880), figs 1–3 (SM J18227), 4–7 (SM J18228).  
 1912 *Androgynoceras maculatum* (Young & Bird); Buckman: pls 45A, B (holotype, WM 493; from bed 590.61)  
 1938 *Androgynoceras maculatum* (Young & Bird); Spath: 126, pl. 20, fig. 6 (BM C.17752, from bed 590.61).  
 1938 *Androgynoceras maculatum* (Young & Bird), var. *rigida*; Spath: 126, pl. 19, figs 2 (BM C.28175, from bed 590.61), 13 (BM C.24601, from bed 590).  
 1961 *Androgynoceras maculatum* (Young & Bird); Dean *et al.*: pl. 70, fig. 4 (BM C.17752; from bed 590.61)  
 1962 *Androgynoceras arcigerens* (Phillips); Howarth: 112, pl. 16, fig. 5 (holotype, BM 17139; from bed 590.61).  
 1976 *Androgynoceras (A.) maculatum* (Young & Bird); Schlegelmilch: 162, pl. 33, fig. 9 (WM 493).  
 1985 *Androgynoceras (Beaniceras) luridum* (Simpson); Phelps: 350, pl. 1, fig. 3 (from bed 583).  
 1985 *Androgynoceras (Aegoceras) sparsicosta* (Trueman); Phelps: 351, pl. 1, fig. 1 (from bed 585).  
 1985 *Androgynoceras (Aegoceras) maculatum* (Young & Bird); Phelps: 350, pl. 2, fig. 8 (probably from bed 590.61).

RANGE. Beds 581–590.63, Maculatum Subzone; 35 specimens.

REMARKS. Ammonites in bed 590.61 have a distinctive style of preservation, where the dark brown or black shell of the ammonite has small near-circular patches of white calcite; such a well-preserved example is figured in Pl. 7, fig. 13. This type of preservation does not occur at any other level and allows the horizon of many of the figured specimens, including the holotype, to be identified precisely, as given in the list of figured specimens above. The lowest specimens in bed 581 are typical examples of the species, being much larger and more developed than is found in transitions from *Aegoceras (Beaniceras) luridum*. The latter transitions are represented by two specimens in bed 583.2 determined as *A. (A.) maculatum* var. *atavum* (see discussion below). The specimen from bed 583 figured by Phelps as *A. (Beaniceras) luridum* is also an *A. maculatum*; it has ribs on the venter that are bold and well developed and are not much reduced on a nearly flat venter as in *B. luridum*.

Phelps (1985: 351) divided the Maculatum Subzone into a lower 'Sparsicosta Zonule' and an upper 'Maculatum Zonule'. His lower division was based on the range of ammonites in the lower part of the Subzone that have low rib densities on their inner whorls of 16–18 ribs per whorl, and were identified as *Androgynoceras (Aegoceras) sparsicosta* (Trueman). Such rib densities are not different from the rib densities of *Aegoceras maculatum*, and in any case *sparsicosta* is not an appropriate name for them. The real *Androgynoceras sparsicosta* (Trueman) (holotype figured Spath, 1938: pl. 5 fig. 7) is a species that develops swollen, quickly expanding whorls and has sharply bituberculate ribs from a diameter of about 25 mm. These features are typical of the genus *Androgynoceras*, and Phelps' (1985: pl. 1, fig. 1) 58 mm diameter ammonite from the lower part of the Maculatum Subzone does not show such features – it is a typical *Aegoceras maculatum*, as are all the specimens in Bairstow's collection. Subdivision of the Maculatum Subzone on the basis of these ammonites is not followed here.

***Aegoceras (A.) maculatum*** (Young & Bird), var. *atavum*  
Spath, 1938 Pl. 7, fig. 8

- 1938 *Androgynoceras maculatum* (Young & Bird), var. *atavum* Spath: 127, pl. 20, fig. 3 (from Gloucestershire).



## PLATE 8

**Fig. 1** *Liparoceras (L.) divaricosta* (Trueman). Bed 596.3, C.39455,  $\times 0.67$ ; wholly septate.

**Fig. 2** *Eoderoceras armatum* (J. Sowerby). Bed 499, near Bay Town, 0.18 m above base of bed, CA 3885,  $\times 1$ .

**Fig. 3** *Biferoceras donovani* Dommergues & Meister. Bed 501.1, near Bay Town, 0.22 m above base of bed, CA 3804; 3a, 3b,  $\times 1$ ; 3c, d,  $\times 2$ ; wholly septate.

RANGE. Two specimens in bed 583.2, Maculatum Subzone.

REMARKS. This record is based on two specimens (C.38873-74) from bed 583.2 that were determined by Spath (1938: 133) as belonging to his var. *atavum*; two other specimens in the same bed (C.348871-72) are typical of the normal variety of *maculatum*. C.38873-74 are both only 34 mm diameter, possibly nearly adult, with reduced ribbing on the nearly flat venter (Pl. 7, fig. 8). The whorl breadth is not as large as in Spath's (1938: 127, pl. 20, fig. 3) type of his variety, but otherwise they are closely similar. Spath (1938: 128) himself remarked that an alternative place for such specimens might be in the genus *Beaniceras*, and it is possible that bed 583.2 might be the horizon from which the holotype of *Aegoceras* (*Beaniceras*) *luridum* was obtained (SM J3274, figured Dean *et al.*, 1961: pl. 69, fig. 6). That holotype is somewhat larger (46 mm diameter), more complete and better preserved than Bairstow's specimens, and no others that are as well-preserved have been found in beds 578–583. Spath's determination as var. *atavum* for these Bairstow collection ammonites is retained here.

*Aegoceras* (*A.*) *maculatum* (Young & Bird), var. *leckenbyi*  
Spath, 1938

1938 *Androgynoceras maculatum* (Young & Bird), var. *leckenbyi*; Spath: 126, pl. 13, fig. 2 (C.3741, from bed 590.1).

1938 *Androgynoceras maculatum* (Young & Bird), var. *arcigerens* (Phillips); Spath: 126, pl. 20, fig. 5 (from Dorset).

RANGE. A single specimen in bed 590.1, Maculatum Subzone.

REMARKS. This variety is kept distinct from the normal type of *A. maculatum* only because it develops massive whorls with 'Liparoceras-type' of ornamentation at sizes of more than 100 mm diameter. Bairstow's specimen is 120 mm diameter, and a Dorset specimen with similar whorls at 120–150 mm diameter was figured by Spath (1938: pl. 20, fig. 5) as *A. maculatum* var. *arcigerens* (Phillips).

*Aegoceras* (*A.*) *lataecosta* (J. de C. Sowerby, 1827)

1827 *Ammonites lataecosta* J. de C. Sowerby: 106, pl. 556, fig. 2.  
1880/82 *Aegoceras lataecosta* (J. de C. Sowerby); Wright: 365 (1882), pl. 32, fig. 1 (1880) (holotype, BM 43916, from Drift, locality unknown).

1938 *Androgynoceras lataecosta* (J. de C. Sowerby); Spath: 135, pl. 19, figs 4 (holotype, BM 43916), 6 (BM C.38562, from Staithes, Yorkshire).

RANGE. Single specimens in beds 591 and 594, Capricornus Subzone.

*Aegoceras* (*A.*) *artigyrus* (Brown, 1837)

1837 *Ammonites artigyrus* Brown: 26, pl. 19, fig. 5.

1843 *Ammonites defossus* Simpson: 15

1855 *Ammonites defossus* Simpson: 48

1884 *Ammonites defossus* Simpson: 78

1889 *Ammonites artigyrus* Brown: 20, pl. 19, fig. 5.

1938 *Androgynoceras artigyrus* (Brown); Spath: 158, pl. 14, fig. 5, pl. 18, fig. 1, pl. 23, figs 3 (holotype, Manchester Museum LL.230, possibly from bed 593), 12, 14.

1973 *Aegoceras maculatum* (Young & Bird); Donovan & Forsey: 14, pl. 4, fig. 1 (SM B11945, paralectotype of *Ammonites defossus* Simpson, 1843).

1973 *Aegoceras* (*Oistoceras*) cf. *figulinum* (Simpson); Donovan & Forsey: 14, pl. 4, fig. 2 (SM B11946, lectotype of *Ammonites defossus* Simpson, 1843, designated by Donovan & Forsey).

1985 *Androgynoceras* (*Aegoceras*) *capricornus* (Schlotheim), morphotype *A. artigyrus*; Phelps: 352, pl. 2, fig. 6.

RANGE. Found by Bairstow only in bed 593, Capricornus Subzone, 4 specimens, but Phelps' figured specimen is from bed 595.2.

REMARKS. Donovan & Forsey's (1973: 14) designation of the Robin Hood's Bay specimen SM B11946 as lectotype of *Ammonites defossus* Simpson, 1843, has consequences for the position of both the genus *Defossiceras* Buckman, 1913, and Simpson's species *defossus*. That lectotype and the paralectotype (SM B11945), also figured for the first time by Donovan & Forsey, are closely similar to each other, and both have robust, quickly expanding whorls and moderately fine ribs on the inner whorls. The robust whorls are not like the slender whorls of *Oistoceras* at similar sizes, and the ribs are more closely spaced on the inner whorls than in *Aegoceras* (*A.*) *maculatum*. The ribs are projected slightly forwards on the venter of both lectotype and paralectotype of *defossus*, but a varying amount of projection of the ribs on the venter occurs in Capricornus Subzone species of *Aegoceras* (*A.*), though it is never as pronounced as in the later subgenus *Oistoceras*. The holotype of *A. (A.) artigyrus* figured by Spath (1938) has similarly robust whorls, the same rib-density on the inner whorls and similar slight forward projection of the ribs on the venter. This is considered here to be the best place for *defossus*, and places the genus *Defossiceras* as a junior synonym of *Aegoceras* (*A.*) (ie. not a synonym of the subgenus *Oistoceras*), and the species *defossus* as a junior synonym of *Aegoceras* (*A.*) *artigyrus*.

Subgenus *BEANICERAS* Buckman, 1913

*Aegoceras* (*Beaniceras*) *luridum* (Simpson, 1855)

1855 *Ammonites luridus* Simpson: 46.

1913 *Beaniceras luridum* (Simpson); Buckman: pl. 73 (holotype, SM J3274).

1961 *Beaniceras luridum* (Simpson); Dean *et al.*: pl. 69, fig. 6 (holotype, SM J3274, possibly from bed 583.2) (see description of Maculatum Subzone, p. 150 below).

RANGE. Beds 578.1–580, Luridum Subzone; 8 specimens; possibly also from bed 583.2, Maculatum Subzone.

REMARKS. Although the eight specimens in beds 578 and 580 are crushed, they are much larger (up to 37 mm diameter) and more compressed than *A. (B.) centaurus* (d'Orbigny), and so can be confidently referred to *A. (B.) luridum*.

Subgenus *OISTOCERAS* Buckman, 1911

*Aegoceras* (*Oistoceras*) *sinuosiforme* Spath, 1938

Pl. 7, fig. 14

1938 *Oistoceras sinuosiforme* Spath: 167, pl. 18, fig. 6, pl. 19, fig. 7 (holotype, BM C.38564), pl. 26, figs 6, 7, 9 (all Spath's figured specimens are from Lincolnshire).

RANGE. Beds 596.2–598.1, Figulinum Subzone; 93 specimens.

REMARKS. *A. (O.) sinuosiforme* has more widely spaced ribs and much less well-developed chevrons on the venter than *A. (O.) figulinum*.

*Aegoceras* (*Oistoceras*) *angulatum* (Quenstedt, 1856)

1856 *Ammonites maculatus angulatus* Quenstedt: 121, pl. 14, fig. 12.

1885 *Ammonites maculatus angulatus* Quenstedt; Quenstedt: 270, pl. 34, fig. 11.

- 1938 *Oistoceras angulatum* (Quenstedt); Spath: 171, pl. 21, fig. 5 (from France), pl. 22, fig. 5 (from Lincolnshire), pl. 26, figs 10, 12 (both from Lincolnshire).
- 1976 *Androgynoceras (Oistoceras) angulatum* (Frebald, 1922) (*sic*); Schlegelmilch: 69, pl. 34, fig. 4 (from Germany).
- 1985 *Androgynoceras (Oistoceras) angulatum* (Quensedt); Phelps: 354, pl. 2, fig. 4 (from Germany).

RANGE. Bed 599, Figulinum Subzone; 1 specimen.

REMARKS. Quenstedt (1856: 121) had specimens from Metzingen and Iggingen, Germany, and he figured one from the former locality. So the original of Quenstedt (1884: pl. 34, fig. 11), refigured by both Schlegelmilch (1976: pl. 34, fig. 11) and Phelps (1985: pl. 2, fig. 4), is almost certainly a syntype and can be designated lectotype; its designation by Schlegelmilch as the neotype is not correct. *A. (O.) angulatum* is more evolute, has more slowly expanding whorls, has no ventro-lateral tubercles, and has fewer ribs on the inner whorls, than *A. (O.) figulinum*. The angle of the ribbing varies between rectiradial and prorsiradial in both species.

### *Aegoceras (Oistoceras) figulinum* (Simpson, 1855)

- 1855 *Ammonites figulinus* Simpson: 47.
- 1855 *Ammonites omissum* Simpson: 47.
- 1876 *Aegoceras defossium* (Simpson); Blake: 282, pl. 8, fig. 9 (SM J17988, see Donovan & Forsey, 1973: 13).
- 1911 *Oistoceras figulinum* (Simpson); Buckman: pl. 26A (holotype, WM 115).
- 1911 *Oistoceras omissum* (Simpson); Buckman: pl. 27 (holotype, WM 502, now lost).
- 1938 *Oistoceras figulinum* (Simpson); Spath: 162, pl. 19, fig. 10 (BM C.17988), pl. 22, fig. 8 (BM 37973a).
- 1938 *Oistoceras omissum* (Simpson); Spath: 170, pl. 21, fig. 3 (BM 38561).
- 1955 *Oistoceras aff. figulinum* (Simpson); Howarth: 161, pl. 11, fig. 4 (SM J35968, from bed 600.4).
- 1976 *Androgynoceras (Oistoceras) figulinum* (Simpson); Schlegelmilch: 69, pl. 34, fig. 3 (WM 115, holotype).
- 1985 *Androgynoceras (Oistoceras) figulinum* (Simpson); Phelps: 353, pl. 2, fig. 1 (from bed 600.2).
- 1987 *Oistoceras figulinum* (Simpson); Dommergues: pl. 11, figs 5, 6.

RANGE. Beds 600.2 and 600.4, Figulinum Subzone; 20 specimens.

REMARKS. This is the most highly developed species of *Oistoceras*, which has fine ribs on the inner whorls, small ventro-lateral tubercles, and well-developed chevrons in the ribs that are connected together into a rudimentary pseudo-keel along the middle of the venter.

### Other species of *Oistoceras* from Yorkshire:

1. *A. (O.) curvicorne* (Schloenbach, 1863); Spath, 1938: 164, pl. 19, fig. 11 (BM C.19228; indeterminate inner whorls), pl. 22, fig. 9 (BM C.6235); both of Spath's figured specimens were probably from Staithes, not Robin Hood's Bay.
2. ?*A. (O.) anguliferum* (Phillips, 1829: 163, pl. 13, fig. 19: 1835: 135, pl. 13, fig. 19: 1875: 270, pl. 13, fig. 19); the type specimen is lost, and Phillips' figure cannot be interpreted.

Genus *ANDROGYNOCERAS* Hyatt, 1867

### *Androgynoceras heterogenes* (Young & Bird, 1828)

- 1828 *Ammonites heterogenes* Young & Bird: 264, pl. 14, fig. 7.

- 1880/82 *Aegoceras heterogenum* (Young & Bird); Wright: 370 (1882), pl. 35, figs 4–6, (1880) (SM J18229), pl. 36, figs 1–4 (1880) (BM C.1870).
- 1912 *Androgynoceras heterogenes* (Young & Bird); Buckman: pl. 46 (holotype, WM 195).
- 1938 *Androgynoceras heterogenes* (Young & Bird); Spath: 113, pl. 13, figs 7a (BM C.19225), 7b (BM C.38457), pl. 20, fig. 2 (BM C.38496, as var. *gigas*, from bed 590.61).

RANGE. Maculatum Subzone: Baird found single specimens in beds 583.2 and 588, but BM C.38496 definitely came from bed 590.61, and the other figured specimens are probably from bed 590.63.

## Order NAUTILOIDEA

Family NAUTILIDAE d'Orbigny, 1840

Genus *CENOCERAS* Hyatt, 1883

### *Cenoceras striatus* (J. Sowerby, 1817)

- 1817 *Nautilus striatus* J. Sowerby: 183, pl. 182 (3 figures, all syntypes, from Dorset).
- 1829 *Ammonites annularis* Phillips: 163, pl. 12, fig. 18: 1835: 134, pl. 12, fig. 18: 1875: 263, pl. 12, fig. 8.
- 1855 *Ammonites heterogeneus* Simpson: 33.
- 1956 *Cenoceras striatus* (J. Sowerby); Kummel: 362, pl. 3, figs 1, 2 (BM 43852, from Dorset).
- 1962 *Cenoceras heterogeneum* (Simpson); Howarth: 96, pl. 13, fig. 1 (holotype, WM 442).
- 1962 *Cenoceras annulare* (Phillips); Howarth: 96, pl. 13, fig. 2 (holotype, WM 62).

RANGE. Baird found single specimens in beds 464.32, 468 (both Simpsoni Subzone) and 505.1 (Taylori Subzone).

## BIOSTRATIGRAPHY

In the description below the ammonite distribution and the placement of the boundaries are discussed for all the zones and subzones in Robin Hood's Bay. Additionally, it is noteworthy that Wine Haven at the south-eastern end of the bay has recently been proposed as the world standard for the definition of the base of the Pliensbachian Stage.

The scheme of ammonite zones used here is based on that regularized by Dean, Donovan & Howarth (1961), with a few later refinements to the details of some of the definitions. Cariou & Hantzpergue (1997) used the same scheme of divisions for the Sinemurian and Lower Pliensbachian in eastern France and the central Mediterranean area. The distribution of the ammonites, on which the biostratigraphical divisions are based, is shown in detail in Figs 21, 22, 24 and 25, which give the number of specimens of each species found in each bed, and a visual indication of the range of each species.

### LOWER SINEMURIAN

**SEMICOSTATUM ZONE, Sauzeanum Subzone**, beds 418–429.64. No ammonites were found in beds 418–420, which are the first 2.48 m of strata exposed above the lowest level to which the tide ever falls in Robin Hood's Bay. Above this, *Euagassicerus* occurs up to about the middle of the subzone, and *Coroniceras (Arietites) alcinoe* occurs in a broad middle part of the subzone; both are



ZONE	SUBZONE	BED	AMMONITES															
			<i>Etaogastoceras resupinatum</i>	<i>Etaogastoceras</i> sp. indet.	<i>Amioceras semicostatum</i>	<i>Amioceras miserabile</i>	<i>Amioceras obliquicostatum</i>	<i>Amioceras</i> sp. indet.	<i>Coroniceras (A.) alcinoe</i>	<i>Coroniceras (A.)</i> sp. indet.	<i>Caenistes brooki</i>	<i>Caenistes turneri</i>	<i>Caenistes</i> sp. indet.	<i>Microderoceras birchi</i>	<i>Microderoceras scoresbyi</i>	<i>Promicroceras capricornoides</i>		
TURNERI	Birchi	446.2																
		446.1																
		445																
		444																
		443.3																1
		443.2																10
		443.1																1
		442.2																
		442.1																
		441.3																
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422.1																		
421.4																		
421.3																		
421.2																		
421.1																		
420																		
419																		
418																		

Fig. 21 Distribution of ammonites in the Lower Sinemurian of Robin Hood's Bay.

characteristic of the Sauzeanum Subzone. *Amioceras semicostatum* is common through most of the subzone.

**TURNERI ZONE, Brooki Subzone**, beds 429.7–433.2. The only ammonites found in the beds that are allocated to this subzone are seven *Caenistes brooki* in the middle part and two *Amioceras* sp. indet. in the middle and lower beds. *Caenistes brooki* probably only occurs in the upper or top part of the subzone (Dean et al., 1961: 453), and the ammonite *Caenistes preplotti* Spath, which is characteristic of the base of the subzone, does not occur in Robin Hood's Bay. So the Brooki Subzone has to be defined according to the boundaries of the adjoining subzones: the highest occurring *Coroniceras (Arietites) alcinoe* in bed 429.64 at the top of the Sauzeanum Subzone defines the base of the Brooki Subzone at the bottom of bed 429.7, and the appearance of *Microderoceras birchi* in bed 433.3 at the base of the Birchi Subzone defines the top of the Brooki Subzone at the top of bed 433.2.

**Birchi Subzone**, beds 433.3–446.2. This subzone is generally considered to correspond to the range of *Microderoceras*: five *M. birchi* occur in bed 433.3, so defining the base of the subzone, and a single

*M. scoresbyi* occurs in bed 441.2 at the middle of the subzone. The top of the subzone is delimited by the appearance of the first *Asteroceras* at the base of the Obtusum Zone. *Caenistes brooki* persists into the basal bed (433.3) of the Birchi Subzone, and the same bed also contains 24 examples of *Caenistes turneri*. *Promicroceras capricornoides* appears just above the lowest part and extends to the top of the subzone. There are no other ammonites in the subzone.

**UPPER SINEMURIAN**

**OBTUSUM ZONE, Obtusum Subzone**, beds 446.31–446.5. The base of both zone and subzone is drawn at the first appearance of a single *Asteroceras* in bed 446.31; that specimen is a definite example of the genus, but is not specifically determinable. The only specimen of *A. obtusum* that was found occurs in the overlying bed 446.32, and *A. confusum* is more common in beds 446.32 and 446.33. *Promicroceras capricornoides* persists into the lowest two beds of the Obtusum Subzone, then is immediately replaced by *P. planicosta* for the remainder of the subzone: the two species do not overlap. Other ammonites are *Xiphoceras dudressieri* (confined to the subzone) and *X. ziphus*, *Epophioceras landriotti* in the upper half and *Cymbites laevigatus* at the top of the subzone.

**Stellare Subzone**, beds 447–455.1. The base of the subzone is placed at the first appearance of the distinctive index species *Asteroceras stellare*, which ranges up to the middle of the subzone, and the top is limited by the first *Eparietites* at the base of the Denotatus subzone. In the upper half of the subzone the index species is replaced by *Asteroceras blakei*, which persists into the overlying subzone. *Aegasteroceras crassum* appears at about the middle of the subzone, then *A. sagittarium* occurs in the top part. *Promicroceras planicosta* is very common in all but the highest beds of the subzone, and 262 specimens were collected by Bairstow. Other ammonites in the subzone are *Cymbites laevigatus*, *Xiphoceras ziphus*, and *Epophioceras landriotti* near the base.

**Denotatus Subzone**, beds 455.2–462. The base of this subzone is placed at the first appearance of the genus *Eparietites*, ie. the new species *E. bairstowi*, which is more evolute and has thicker and more massive whorls than any other *Eparietites*. The main species ranging through the middle and upper parts and up into the Simpsoni Subzone is *E. impendens*. From the subzone below *Asteroceras blakei*, *Aegasteroceras crassum* and *A. sagittarium* persist into the bottom and middle parts of the Denotatus Subzone. *Cymbites laevigatus* occurs throughout the subzone, and the Schlotheimid *Angulaticeras* sp. indet. occurs in the top two beds.

**OXYNOTUM ZONE, Simpsoni Subzone**, beds 463–471. The base of the subzone is placed at the first appearance of the index species *Oxynoticeras simpsoni* in bed 363, where there are two large specimens that show typical characters of the species; there are four more specimens in bed 464.3, poorly preserved examples in beds 465 and 466, then the species becomes common in bed 467 and 468 in the mid to upper part of the subzone.

From the subzone below, *Eparietites impendens* persists into beds 463–464.32, where it overlaps with *O. simpsoni* in the bottom 1.68 m of the Simpsoni Subzone. In fact at its highest level in bed 464.32 there are many typical *E. impendens*. A similar overlap between *E. impendens* and *O. simpsoni* is also found in the top part of the Frodingham Ironstone near Scunthorpe, Lincolnshire.

*Gagaticeras* is characteristic of the upper half of the Simpsoni Subzone, from bed 467 upwards, where there are many specimens belonging to four species. *Palaeoecioceras* occurs in bed 467, and

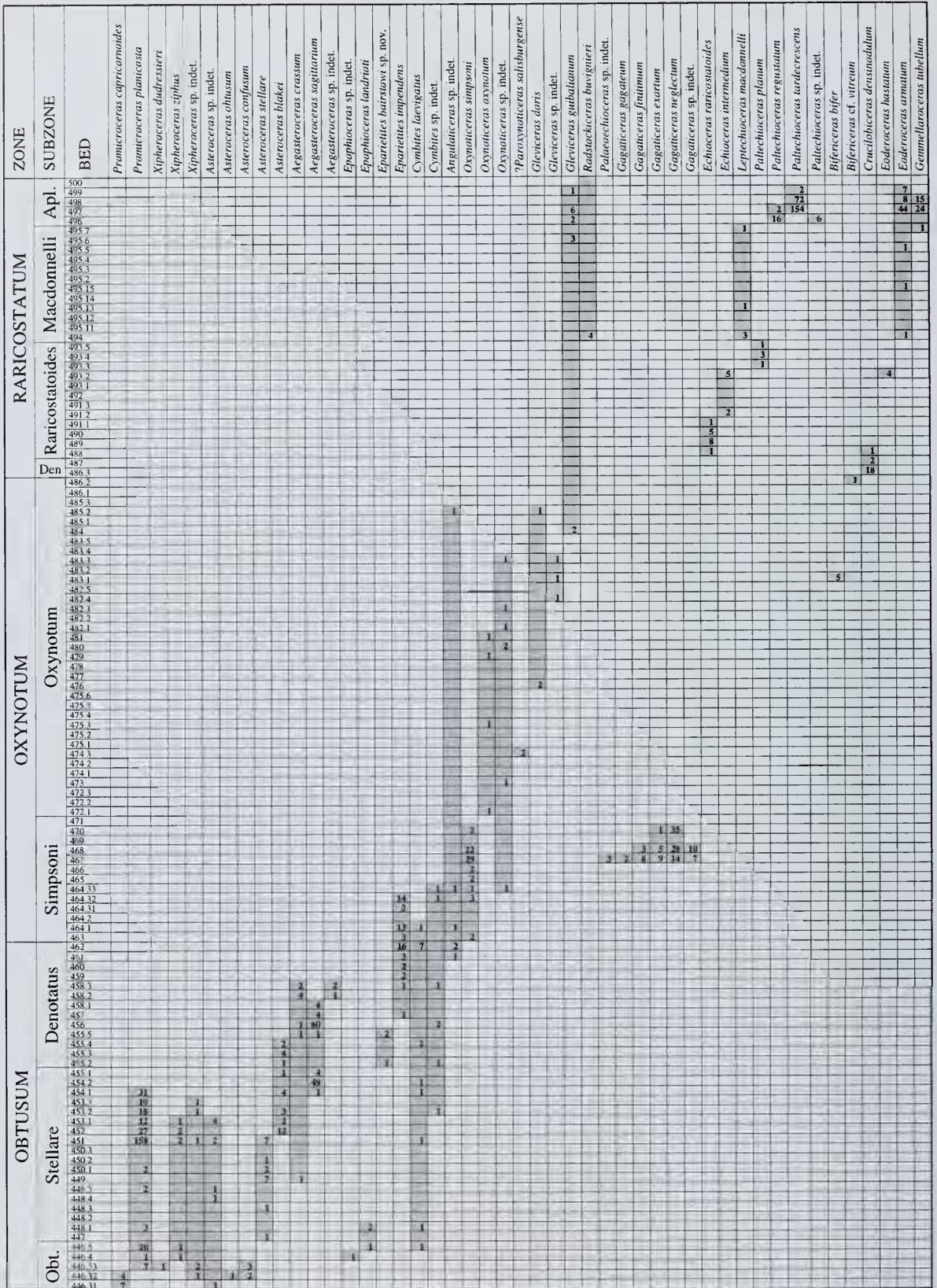


Fig. 22 Distribution of ammonites in the Upper Sinemurian of Robin Hood's Bay.

*Cymbites laevigatus* and *Angulaticeras* sp. indet. occur in the lower half of the subzone.

**Oxynotum Subzone**, beds 472.1–486.2. More involute and compressed *Oxynoticer* like *O. oxynotum* rather than *O. simpsoni* first occur in bed 472.1, so the base of the subzone is placed at that level. Better specimens occur higher in the subzone, as well as fragments of large specimens. Other oxynoticeratids present are two possible specimens of *Paroxynoticer* *salisburgense* in the lower half, and *Glevicer* *doris* and *G. guibalianum* in the upper half of the subzone. *Angulaticeras* sp. indet., *Bifericeras bifer* and *B. cf. vitreum*, also occur in the upper half of the subzone.

**RARICOSTATUM ZONE, Densinodulum Subzone**, beds 486.3 and 487. The base of the subzone is placed at the first appearance of *Crucilobicer* in bed 486.3 and the top is limited by the first occurrence of *Echioceras* in bed 488 marking the base of the *Raricostatoides* Subzone. So the *Densinodulum* Subzone consists only of the 1.0 m thick beds 486.3 and 487. *C. densinodulum* is abundant in bed 486.3, but there are no other ammonites in the subzone.

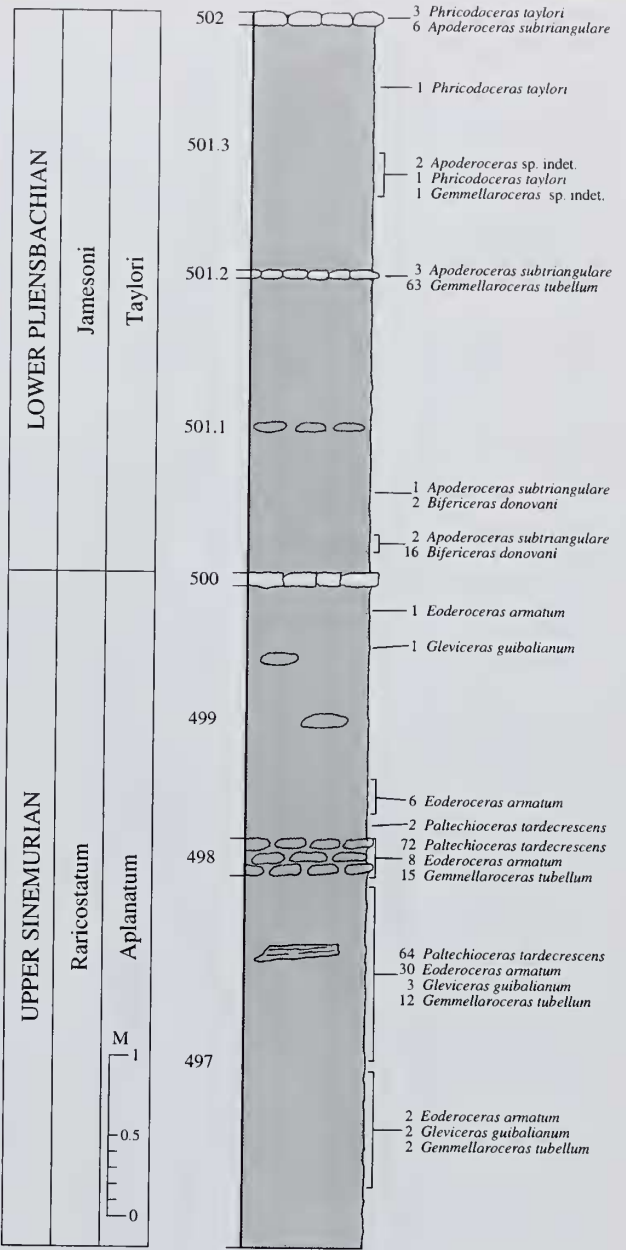
**Raricostatoides Subzone**, beds 488–493.5. The base of the subzone is placed at the first appearance of *Echioceras*: *E. raricostatoides* in the basal one-third of the subzone is followed by *E. intermedium* in the middle part, then by *Paltechioceras planum* in the upper one-third of the subzone. *Crucilobicer densinodulum* persists from the subzone below into the basal bed, and the only other ammonite in the subzone is *Eoderoceras hastatum* in the upper part.

**Macdonnelli Subzone**, beds 494–495.7. This subzone is based on the range of the index species *Leptechioceras macdonnelli*, which occurs in the top and bottom beds and does not range higher. The earliest *Eoderoceras armatum* occurs in the bottom bed, and the first Polymorphitid, *Gemmellaroceras tubellum*, occurs in the top bed. The only other ammonites present are the Oxynoticeratids *Glevicer* *guibalianum* near the top of the subzone and *Radstockiceras buvignieri* in the bottom bed. The latter record seems to be the first provable occurrence of *Radstockiceras* in the *Raricostatum* Zone.

**Aplanatum Subzone**, beds 496–500. The base of the subzone is placed at the first occurrence of *Paltechioceras regustatum*, and *P. tardecrescens* (of which *P. aplanatum* is a synonym) becomes abundant in the middle and upper parts of the subzone. *Paltechioceras* first occurs in the top part of the *Raricostatoides* Subzone, but the genus is much more common in the *Aplanatum* Subzone and does not range higher. Another ammonite that is characteristic of the *Aplanatum* Subzone is *Eoderoceras armatum*, which first appears as rare examples in the *Macdonnelli* Subzone, but becomes much more common in the *Aplanatum* Subzone; it ranges up to 0.15 m below the top of bed 499, but it does not occur higher and does not overlap with *Apodoceras* in the *Taylori* Subzone. *Gemmellaroceras tubellum* is common in the middle part, and *Glevicer* *guibalianum* occurs in the lower part of the subzone.

**LOWER PLIENSCHACHIAN**

The exposures at the base of the cliff in Wine Haven, Robin Hood's Bay, have recently been proposed as the Global Stratotype Section and Point (GSSP) for the base of the Pliensbachian Stage (Hesselbo *et al.*, 2000). The sequence across the Sinemurian/Pliensbachian boundary is sufficiently expanded and rich in ammonites here to be suitable for such an important global reference section. Hesselbo *et al.*'s (2000: 604, fig. 4) stratigraphical sequence is closely similar to the sequence described here, as are their ammonite records and identifications. Their bed 73 at the base of the Pliensbachian is the



**Fig. 23** The distribution of ammonites close to the Sinemurian/Pliensbachian boundary in Robin Hood's Bay. The ammonites listed include those collected from the exposures across the boundary at both Wine Haven and the foreshore immediately east of Robin Hood's Bay town; there are no significant differences in the distribution of ammonites at the two exposures.

same as bed 501 here (see the correlation table of Fig. 19), and their photograph (Hesselbo *et al.* 2000: fig. 3) shows the nodules of their bed 72 (=bed 500 here) and the basal reference point of the Pliensbachian low in the cliff at Wine Haven.

Fig. 23 shows details of the stratigraphical distribution of Bairstow's ammonites at the Sinemurian/Pliensbachian boundary. The first ammonites to occur above the boundary are 16 *Bifericeras donovani* Dommergues & Meister (one is figured in Pl. 8, fig. 3) and

two *Apoderoceras subtriangulare* (Young & Bird) (Pl. 5, fig. 8) 0.13–0.22 m above the bottom of bed 501.1. Hesselbo *et al.* (2000) did not find ammonites in the 1.8 m of strata below the base of the Pliensbachian (ie. in the nodules of bed 500 and the shales of bed 499). Bairstow did not find ammonites in bed 500, but he collected six specimens of *Eoderoceras armatum* from bed 499 in the middle of the bay near Robin Hood's Bay town. These are well-preserved, readily identifiable examples of the species (one is figured in Pl. 8, fig. 2), and Bairstow's records show that they were collected 0.15–0.37 m above the base of that bed. A single *E. armatum*, less well-preserved than those lower down, but still readily identifiable with that species, was collected from Wine Haven high in bed 499, only 0.15 m from the top. The thickness of strata across the

Sinemurian/Pliensbachian boundary from which no ammonites have been collected is thus reduced to only 0.36 m.

**JAMESONI ZONE, Taylori Subzone**, beds 501.1–537. The base of the subzone (and the Jamesoni Zone, and the Pliensbachian Stage) is placed at the bottom of bed 501.1, which contains the lowest occurrence of the characteristic genus *Apoderoceras*, and this is the only horizon at which *Bifericeras donovani* Dommergues & Meister occurs. *Phricodoceras taylori* and other species of *Phricodoceras* are present through much of the subzone and do not range higher. Many examples of *Gemmellaroceras tubellum* are found near the base of the subzone, and the larger species *G. rutilans* occurs in the top part. A single specimen of *Radstockiceras buvigneri* was also

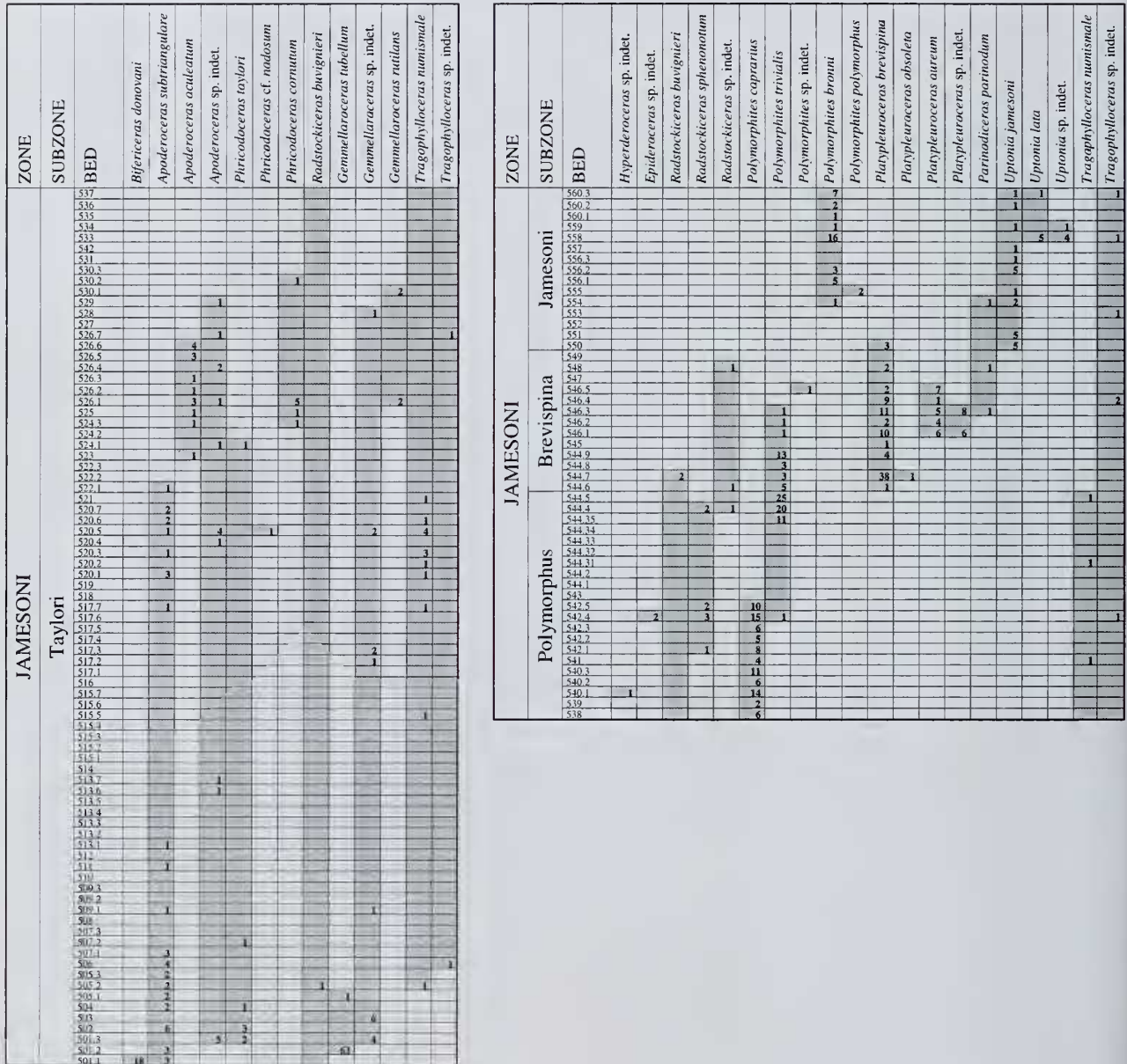


Fig. 24 Distribution of ammonites in the Jamesoni Zone, Lower Pliensbachian, of Robin Hood's Bay.



typical features of the species. The more evolute *P. aureum* occurs in the middle part of the subzone, and the more finely ribbed *P. obsoleta* is represented by only one specimen in Bairstow's collection from the lower part of the subzone. *Polymorphites trivialis* is common in the lower and middle parts of the subzone, and there are rare occurrences of *Radstockiceras*, *Parinodiceras* and *Tragophylloceras*.

**Jamesoni Subzone**, beds 550–560.3 (except the top 0.08m). The base of the Jamesoni Subzone is placed at the first occurrence of *Uptonia jamesoni* in bed 550, and the index species then extends through the full thickness of the subzone, to which it is confined. The more finely ribbed *U. lata* occurs less commonly in the upper half of the subzone, and *Polymorphites bronni* is also characteristic of the upper half of the subzone. The only other ammonites in the subzone are the highest occurring specimens of *Platypleuroceras brevispina* in bed 550, *Polymorphites polymorphus* at the middle of the subzone, and rare examples of *Parinodiceras* and *Tragophylloceras*.

**IBEX ZONE, Masseanum and Valdani Subzones**, beds 560.3 (top 0.08 m)–577. These two subzones are delimited according to the distribution of species of *Tropidoceras* and *Acanthopleuroceras*: *Tropidoceras* occurs in both subzones and *Acanthopleuroceras* only in the Valdani Subzone. Unfortunately ammonites are rare in this interval in Robin Hood's Bay, and the few examples of these genera are not well-preserved. None, however, have the definite bituberculate ribs of *Acanthopleuroceras*, so they all have to be identified as *Tropidoceras*, in which umbilical tubercles are much reduced or absent. The lowest example (Pl. 7, fig. 10) from the top 0.08 m of bed 560.3 and another (Pl. 7, fig. 11) from near the bottom of bed 568 are best determined as *T. futtereri* (Spath), while several specimens from the boundary of beds 567 and 568 have the much more massive ribs at larger sizes and the more widely spaced ribs of *T. masseanum* (d'Orbigny), var. *rotundum* (Futterer). The base of the Masseanum Subzone (and of the Ibex Zone) is placed 0.08 m below the top of bed 560.3 to include this earliest *T. futtereri*, and bed 568 probably belongs to the same subzone.

In the absence of *Acanthopleuroceras* there is no good evidence for the position of the base of the Valdani Subzone, so it is placed provisionally at the bottom of bed 571 from the occurrence of *Liparoceras (L.) heptangulare*. There are two more specimens of that species in beds 575 and 577. According to Spath (1938: 59) *L. (L.) heptangulare* might be confined to the Valdani Subzone (ie. Spath's 'Centaurus Subzone'), so its presence in beds 571–577 (7.66 m thick) suggests that they are probably of Valdani Subzone age.

The only other ammonites in either subzone are two *Liparoceras (L.) cheltiense* low in the Masseanum Subzone, one *Tragophylloceras loscombi* high in the same subzone, and *Lytoceras fimbriatum* in the upper part of the Masseanum Subzone and throughout the Valdani Subzone. The latter species becomes more common in the Luridum Subzone.

**Luridum Subzone**, beds 578.1–580. The presence of eight *Aegoceras (Beaniceras) luridum* in beds 578.1, 578.5 and 580 is sufficient evidence to refer beds 578 to 580 to the Luridum Subzone. Other ammonites in this subzone are a single *Liparoceras (L.)* cf. *naptonense*, two *Liparoceras (L.)* sp. indet. and 14 examples of *Lytoceras fimbriatum*.

**DAVOEI ZONE, Maculatum Subzone**, beds 581–590.7. The base of this zone and subzone is placed at the bottom of bed 581 which contains the lowest *Aegoceras (A.) maculatum* (Pl. 7, fig. 12). Two more, typical, examples occur in bed 582.3, then there are many well-preserved specimens at higher levels, especially in beds 590.61 and 590.63. Other ammonites in the Maculatum Subzone are *A. (A.) maculatum* vars *atavum* and *leckenbyi*, *Liparoceras (L.)* cf.

*naptonense*, *Androgynoceras heterogenes* and *Lytoceras* sp. indet. See remarks on the identification of *Aegoceras maculatum* (p. 141) for discussion of the division of the Maculatum Subzone into smaller units.

**Capricornus Subzone**, beds 591–596.1. The base of the subzone is placed at earliest occurrence of *Aegoceras (A.) lataecosta* in bed 591. This is 1.83 m above the highest *A. (A.) maculatum* in bed 590.63, but the intervening strata (beds 590.64–590.7) did not yield any ammonites and are retained in the Maculatum Subzone. The only other ammonites in the subzone are *A. (A.) artigyrus*, which has more massive whorls and coarser ribbing than *lataecosta*, and a number of poorly preserved *Aegoceras (A.)* sp. indet.

**Figulinum Subzone**, beds 596.2–600.5. This subzone is based on the range of the subgenus *Oistoceras*. The index species, *Aegoceras (Oistoceras) figulinum*, occurs in beds 600.2 and 600.4 near the top of the subzone, but the base of the subzone is placed at the lowest appearance of *A. (O.) sinuosiforme* in bed 596.2. This and *A. (O.) angulatum* in bed 600.2 have more widely spaced ribs than *figulinum*, especially on the inner whorls. The only other ammonite in the subzone is a single *Liparoceras (L.) divaricosta* in bed 596.3 (Pl. 8, fig. 1).

The top of the subzone is limited by the base of the Stokesi Subzone (Margaritatus Zone, Upper Pliensbachian), which is placed at the first appearance of *Amaltheus stokesi* in bed 600.6. There are other examples of *A. stokesi* in bed 600.8 and at higher levels in the Stokesi Subzone. *Aegoceras (Oistoceras) figulinum* and *Amaltheus stokesi* are confined to their respective subzones in Robin Hood's Bay and their ranges do not overlap.

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